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THE HISTORY OF AGRICULTURE IN WALES.

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In some respects the history of agriculture has been the same in every country. It began with the first efforts of primitive man to grow his own food. He had been a herdsman for long before he became a husbandman and it is natural to suppose that he did not take kindly to the plough. Once he became a member of a settled community, however, he realised that though it imposed restrictions upon his former freedom, the plough was necessary for his existence. Agriculture, as distinct from the herding of stock, pre-supposes more or less settled conditions, though it is not necessary to assume that those who practised it in early times were permanently fixed to the same spot.

Wales has always been mainly a pastoral country. Its physical character and its climate render it more suitable for the breeding of live stock than for the production of corn. Without raising the question of cause and effect in this connection, it may also perhaps be said that in general the Welsh are by nature stockmen rather than ploughmen. But while their main interest has always been in their flocks and herds, there is, nevertheless, ample evidence that they were familiar with tillage from an early period. Of secondary importance to him, no doubt, and practised only on a small scale, still the medieval Welshman was not without considerable knowledge of the operations as well as of the worries associated with the cultivation of crops.

In the pages of Giraldus Cambrensis we have an interesting, if brief, account of the general character of 12th century Welsh agriculture. He tells us that the whole people were trained to war, and when the trumpet sounded the alarm, the husbandman rushed as eagerly from his plough as the courtier from the court. Their agricultural pursuits did not claim their attention all the year round, for the soil was only ploughed once in March and April for oats and was not ploughed in summer or winter for wheat. Almost all the people lived on the produce of their herds, with oats, cheese, milk and butter, and they ate flesh in larger proportions than bread.[1]

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[1] *Description of Wales*, I, VIII.

On a later page he says that they did not inhabit towns or villages, but led a solitary life in the woods, on the borders of which they did not erect stone buildings, but contented themselves with small huts made of boughs of trees twisted together, constructed with little labour and expense and sufficient to endure throughout the year. He adds that they had neither orchards nor gardens and that little land was cultivated, the greater part being pasturage. He had observed also that they seldom yoked less than four oxen to their ploughs and that the driver walked backwards in front of the team.[2]

Here we have a pastoral people, with no permanent habitations, who in the event of an invasion could immediately remove their chief means of sustenance out of the way, and who normally, after the corn was sown in the spring, moved with their stock into the uplands for the summer months, returning in time to harvest their corn in the lowlands and to prepare their dwellings for the winter. Nevertheless, while this description is doubtless true in general of the parts of Wales through which Giraldus passed in the course of his famous journey, it is evident that there were parts of the country, both before and after his time, where corn was grown to a much greater extent than his words would imply. He himself informs us in another place[3] that Anglesey was incomparably more fertile in wheat than any other part of Wales, from which arose, he says, the Welsh proverb, *Môn mam Cymru.* He adds that when crops had been defective in all other parts of the country, Anglesey from its abundant produce, had been able to supply all Wales. This may perhaps be an exaggeration, but there can be no doubt in regard to the reputation of Anglesey for productiveness. It was, however, not the only part of Wales famous for its corn, for as early at least as the 14th century, the wheat of Maes Gwenith in Gwent and the barley of Llonion in Pembrokeshire were proverbial.[4]

The system of land tenure in early Wales differed materially from what we are familiar with in the manorial system in England, being intricately bound up with the tribal organisation of Welsh society, the basis of which was blood-relationship. It is not possible or necessary here to describe it in detail, but some of the features of the system may be alluded to. According to the Welsh laws, there could be no land without a lord. Every division of the country, therefore, was, in theory at least, subject to a lord or king, who had a direct interest in the land in his own territory. Apart from the lord, there were two classes of persons occupying the

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[2] Ib. I, XVII.
[3] *Itinerary through Wales*, II, VII.
[4] *Myv. Arch.*, 2nd Ed., p. 398.

land, the *uchelwr*, or *breyr*, and the *taeog*, or *aillt*. The former were free tribesmen of pure Welsh descent and formed the governing and privileged class. The latter were servile cultivators, resembling in some respects, though differing in others from, the villeins of an English manor. The free tribesmen, who occupied the bulk of the land in each district, were not land-owners in their individual capacity. The land belonged to the kindred, or *gwely*, a definite group of relations descended from a common ancestor, but the head or chief of the kindred (*penteulu*) was a landowner in the sense that in him for the time being were vested the tribal rights of his kindred.[5] As such he enjoyed a status that conferred certain privileges upon him and imposed certain obligations as well. The Welsh tribesmen, forming a kind of oligarchy, jealously guarding its privileges, represented no doubt a conquering race which had imposed its rule and its customs upon the country. The dependent class of servile cultivators, or bond tenants (*taeog*), were to a large extent probably the descendants of the conquered people whom the invaders found in possession of the land.[6]

The *uchelwr* class held their land subject to certain conditions. Every district of the country was divided for taxation purposes into *trefs* (hamlets or townships). Each *tref* occupied by the free tribesmen rendered to the lord, or king, annually for the support of his household, a contribution, which originally consisted of a defined quantity of food, known as a *gwestfa*. Long before the conquest of Wales by Edward I, this annual food-rent had been largely, if not entirely, commuted into a fixed money payment of one pound, known as the "tunc" or "fealty" pound. It is to be observed that this payment, like the original *gwestfa*, which it represented, was a collective payment made by each *tref* and not by the *uchelwr* class as individuals. It was a fixed charge upon the land itself. In addition to this payment, the tribesmen paid the lord, or king, certain dues defined by law, on succeeding to their rights in the tribal land (*ebediw*) and on the marriage of their daughters (*amobr*). As a matter of course, they were called upon to render military service. Their land was strictly entailed and the rights of every holder of land was effectively safeguarded by tribal custom.

The position of the bond tenants (*taeog* or *aillt*) was different both in theory and practice from that of the free tribesmen. They, too, occupied *trefs* (*taeog-dref*, or bond hamlet) and had recognised rights of which they could not be legally deprived, but were naturally

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5 Seebohm, *Tribal System in Wales*, 2nd Ed., Chap. IV.
6 Lloyd, *Early Welsh Agriculture*, p. 4.

debarred from the privileges of the free tribesmen. The conditions on which they held their land were, originally at least, somewhat onerous. Here again the unit for taxation was the *tref.* Each *taeog-dref* had to render to the lord, or king, in summer and winter a collective food-gift (*dawn-bwyd*) for the support of the court. The bond tenants had also to render certain other services and in particular to furnish free accommodation to certain court officials at various times during their " progress " (*cylch*) through the lord's dominions. There was in every district subject to a lord (*cymwd*), a certain specified portion of land set aside for the lord's own use, which, by law, consisted of two *trefs.* One of these was his *maerdref,* the hamlet attached to the lord's, or king's, own residence. The *taeog* tenants of the *maerdref* held their land on condition that they furnished all the necessary labour for the cultivation of the board-land (*tir-bwrdd*), the part of the *maerdref* that was set aside for the cultivation of the lord's own crops, as well as to tend the lord's herds. The *taeog* tenant, whether he lived in the *maerdref* or in any other *taeog-dref,* was subject to certain impositions, which need not be set out here, and his servile position is made clear by the restrictions placed upon him by Welsh law. He could not, for example, keep any dog that was worth more than fourpence, so that he could not hunt the lord's game. Nor was he allowed to possess any bird that exceeded the value of a hen, which as effectively prevented him from hawking. His sons could not, without the lord's consent, be trained for certain professions, and there were certain animals and products that he could not dispose of except after they had been offered to, and refused by, the lord. At the same time, the *taeog* tenant had his own *tyddyn,* or homestead, furniture and tools, and he generally owned cattle and other stock. He also had a recognised right to a share in the land of the *taeog-dref,* of which he could not be dispossessed. This, however, did not mean that he occupied permanently the same piece of land. The land of the *tref* was unenclosed, each *taeog* having his share allotted to him every season. Moreover, on the death of a *taeog,* his land went into the common stock, and was equally divided between all the *taeog* tenants in the *tref.* It followed, therefore, that as tenants from time to time died and there were always sons of tenants to be provided with land as the law required, there was a constant redistribution of the land in the *tref.* The *taeog,* however, was not at the redistribution of land to be moved from his *tyddyn* if that could be avoided. The *tyddyn,* whether of a free tribesman or a *taeog,* consisted simply of the tenant's dwelling house (built in the manner described by Giraldus), the necessary buildings for his stock, his fold and stack-

yard, and did not include any land. The *taeog*, therefore, like the free tribesman, had in regard to his *tyddyn*, a considerable degree of security of tenure, which might under normal conditions amount to something approaching ownership, although Welsh law did not recognise individual ownership of land. It is necessary to bear in mind that the dwellings, even in the *taeog-dref*, were not grouped together into villages, or hamlets, in the modern sense, but were dotted about the country side as convenience might dictate. We have the testimony of Giraldus that this is what he actually saw in the 12th c ntu:y. It is natural to suppose, however, that in the *maer-dref*, for example, the *taeog* tenants would for convenience often arrange their *tyddyns* together in groups, and it is from such groups perhaps that villages arose in later times. There might sometimes be a *taeog* settlement on the land of an *uchelwr*, but apart from the existence of such a class and what would appear to be their inferior social position as compared with the *taeog* tenants of the lord. or king, little is known about them.

The land occupied by the free tribesmen was also subject to redistribution from time to time on the death of the head of the family group concerned. It was divided by strict rule on a purely family basis, the descendants of the common ancestor of the family having equal rights. After the division every fourth generation, the individual inheritors of the family land became the heads of their own family groups, amongst whom in the fourth generation, the land would be divided again in the same manner.

A system such as has been described which, with the passing of time must have become exceedingly complicated, was clearly only applicable to a certain stage of social and economic development. It was, however, largely in operation, in North Wales at least, at the time of the Edwardian Conquest in 1282; as the official records made shortly after that event clearly show. But it was breaking down and had already been modified in many places. After the Conquest the Welsh system was adapted, at least in theory, so as to fit in as well as circumstances would allow with the English system, to which, in practice, certain features of it bore some resemblance. Certain Welsh land units were spoken of in terms of manors, the *uchelwrs* became nominally free tenants and the *taeogs* became villeins. This, of course, had been done in parts of Wales long before 1282. But although the application of new methods tended to bring things into line with English custom, the old system remained largely in operation till it was abolished with the incorporation of Wales with England under Henry VIII. The position of the *taeog* tenants in the 15th century is illustrated in an Anglesey

deed of 1448, which reads as follows: "Ednyfed Fychan ab Ednyfed, Dafydd ab Gruffydd and Howel ab Dafydd ab Ryrid, free tenants of our Lord the King in the township of Rhandir Gadog, have given and confirmed unto William ab Gruffydd ab Gwilym, Esquire, free tenant of Porthamel, seven of our natives (*nativi*, or *taeog* tenants), namely, Howel, Matto and Llewelyn ab Dafydd Dew; Dafydd and Howel ab Matto ab Dafydd Dew; Llewelyn ab Evan Goch and Ieuan ab Evan Ddu, with their successors procreated and to be procreated and all their goods, chattels, etc., to have, etc., our aforesaid natives, etc., to the said William Gruffydd ab Gwilym, his heirs and assigns for ever. Dated at Rhandir Gadog, June 20th, 27th of Henry VI."[7]

Tillage operations, of which ploughing was the chief, were subject to strict rules under Welsh law. Such rules were essential in view of the fact that in the *taeog-drefs* at least and to some extent perhaps too in the free *trefs*, the method of working depended upon the co-operation of the tenants as a group. Co-tillage required that each should perform his share of the common task, but each also had his legal rights which had to be protected. The arable land of the *tref* was ploughed by means of a joint team consisting normally of eight oxen. In an ordinary *tref* there would no doubt be several such teams at work during the ploughing season. Each team was expected to plough so many furrows of a customary length and width, the proper number of which constituted an *erw* or *cyfar*. The *erw* was a full day's work and was the customary unit measure for arable land. In actual measurement it varied considerably in different parts of Wales. The *erw* of Gwynedd was 1,440 square yards, that of Gwent was 729, and the erw of Dyfed 512 square yards.[8] When the team had ploughed twelve separate *erws*, the latter were then allotted according to rule between those who had helped in the ploughing. From that time till after harvest, the allotted *erw* belonged to the individual tenant, who was protected by law against damage to his crops by straying stock. Although land was sometimes ploughed in the autumn, spring ploughing, as noted by Giraldus, was the general practice and it began according to law on the 9th of February.

By the 14th century what may be described as mixed farming was fairly general in the lowland parts of Wales, though the arable land no doubt formed but a small proportion of the whole. There was a considerable variety of crops, including all the cereals, peas, beans and flax. Some idea of the position of affairs as regards the produce in a particular area may be obtained from the returns relating to the Manor of Aberffraw in Anglesey in 1320-40.[9] For

comparison, the returns of the parish of Aberffraw for 1924 are also given.[10]

	Value in 1320-40	*No. in* 1320-40		*No. in* 1924.
Cows ...	... 3s. 4d. per head		262	419 (Dairy cattle)
Oxen ...	... 5s. ,,	137		
3 yr. old cattle ...	... 2s. 6d. ,,	38		
2 yr. olds ...	... 2s. ,,	91		1,248 (Other cattle)
			266	
Total cattle			528	1,667
Horses ...	... 5s. ,,	71		
Mares ...	... 5s. ,,	36		
Total horses			107	254
Sheep ...	... 6d. ,,		735	4,509

In the fourteenth century, wheat, barley and oats were grown and the quantity of each on hand at the time the record was made was:

Wheat	115	crannocs at 2s. 6d. per crannoc	(crannoc = 8 bush.)
Barley	70	,, ,, 1s. 4d. ,,	,,
Oats	307	,, ,, 2s. 0d. ,,	,,
	492		

The total value of the produce, stock and corn, given in the record is stated to be £188.

We have no information as to the area from which the corn had been produced, nor do we know whether the quantities recorded were the total produced on the manor land. In any case, it will be seen that oats were by far the most important cereal. This is also true 600 years later, for out of a total corn area of about 650 acres in the parish in 1924, over 600 acres were under oats. The number of holdings possessing cattle in the manor was 68. To-day the number in the parish is 105, of which 76 are of a size not exceeding 50 acres. If we may assume that the modern parish of Aberffraw represents approximately the earlier manor, which was, as is known, the manor attached to the chief residence of the Princes of Gwynedd, it is clear that the total produce from the land has been greatly increased under modern conditions.

While production was no doubt low and the methods of cultivation largely ineffective, there was in the fourteenth century a considerable volume of sound knowledge in regard to land and live stock. There is evidence that husbandry was receiving attention from the Welsh

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7 Llwyd, *Beaumaris Bay*, p. 31.

8 Palmer and Owen, *Ancient Tenures*, 2nd Ed.. p. 22.

9 Seebohm, *Tribal System*, p. 23.

10 Supplied through the courtesy of the Statistical Branch of the Ministry of Agriculture.

scholars of the period. The Red Book of Hergest contains a Welsh treatise on the subject,[11] which though not an original work, is of much interest as showing that the subject was not only claiming attention but that there were men in Wales who were acquainted with works on agriculture written in England. The treatise in question is, in fact, an abridgement in Welsh of Walter of Henley's *Le Dite de Hosebondrie,* written in the thirteenth century. Walter's book was written in the Norman-French of the period and there appeared very soon an English translation, attributed to Robert Grosseteste, Bishop of Lincoln, who was himself the author of a well-known work on the management of estates. The unknown Welsh translator adapts the work to Welsh conditions by rendering some of the technical expressions of the original in terms familiar to his Welsh readers. "Acre" becomes *erw*. "free tenants" become *uchelwyr* and "customary tenants" appear as *meibon eillon*. Then he gives Walter's very excellent directions as to ploughing, change of seed, the preservation of manure and other things.

An average crop of wheat in the fourteenth century seems to have been about 12 bushels to the acre from a seeding of 3 to 4 bushels. Barley was sown at the rate of 6 or 7 bushels and might yield from 18 to 25. Oats had a heavier seeding up to 8 bushels and gave a crop of from 16 to 24 bushels. The yield from rye and peas appears to have been similar to that of wheat, but beans from a seeding of 6 or 7 bushels to the acre might yield on suitable land up to 28 bushels.[12] The generally expected yield of all these crops was three or four times the amount sown, and was quite equal to that obtained in England although the rate of sowing was higher in Wales.[13]

When towns began to grow around the military centres established after the Conquest, a new demand for corn and other produce arose and regular markets and fairs were established in many places where none existed before. The local supply of corn, however, was often insufficient in the fourteenth century to supply the needs of these towns. Thus we find corn from Anglesey, Chester and Ireland brought to Carnarvon on more than one occasion for this reason.[14]

Though there is evidence as to different varieties of the same cereal being in cultivation as early as the fourteenth century, there is little to indicate their distinctive character. In the 16th century, however, several varieties of wheat were grown in North-East Wales and their character is indicated to some extent in the names by

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11 Transcribed by Prof. Ifor Williams for the *Bulletin of the Board of Celtic Studies*, Vol. II, Pt. I, Dec.. 1923.
12 See *Black Book of St. David's.*

which they are described.[15] It is not easy to interpret all these, but it is fairly clear that the varieties included a small white, a grey pollard (beardless), a large red, and another known as Welsh wheat. These, with the exception of the last, may probably be identified with varieties in cultivation in England in the same period as well as later. At the beginning of the seventeenth century two varieties of winter wheat were grown in Pembrokeshire,[16] one bearded and the other a beardless kind known as "notted," which was grown in England and there known also as notted, or pollard.

Even in districts where there was a considerable area of land regularly under corn of various kinds, the crops do not appear to have been grown in the systematic rotation implied in the English three-field system. Fallowing was general but the bare fallow did not come at regular intervals.[17] There were many districts no doubt where, as in earlier times, corn was grown on the same land year after year until the soil was exhaused. It would then be left to seed itself, another piece in the meantime being ploughed up. This is a process that was not peculiar to Wales or to the fourteenth century. The manure collected from the stables, the cattle-yards and the sheep-folds could scarcely have been enough in quantity to prevent the impoverishment of the arable land. Marl was used fairly extensively in some districts and, as marl was expensive,[18] it may have been made to go further by mixing with pond and ditch cleanings. It is doubtful whether lime was employed to more than a small extent for the improvement of land before the seventeenth century. Shell-sand as a manure was first used in Anglesey about 1650.[19] A still longer period was to elapse before new crops were introduced and a new system of cropping devised, which would increase production and conserve the fertility of the soil at the same time. This only became possible with the introduction of the turnip as a field crop in the latter half of the eighteenth century.

It has often been pointed out how, under the English common field system, it was impossible to expect any improvement to be made in the land or in the stock. The same may be said of Wales. It is true, however, that efforts at improvements are recognised in the Welsh laws, for it is provided that the occupier might retain land that had been manured for a fixed period after the usual redistribu-

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13 Lord Ernle, *English Farming Past and Present*, p. 10.
14 Lewis, *The Mediaeval Boroughs of Snowdonia*, p. 184.
15 W. Salesbury, *Llysieulyfr Meddyginiaethol*, Ed. E. Stanton Roberts, p. 168.
16 George Owen, *Description of Pembrokeshire.*
17 Cf. Rees, *South Wales and the March*, p. 180.

tion, a principle that took English law a very long time to recognise. But when the specified period had expired, the land had to be treated like all the rest. In the actual improvement of the land in the hands of the ordinary cultivators there was very little before the sixteenth century. Changes in the general agricultural system took place locally as a result of economic or other causes, and the social position of the different classes of people on the land, no doubt, changed. There are some signs of progress also in places. Apples for cider-making came to be cultivated in Monmouthshire in the early part of the fourteenth century.[20] The fifteenth century, beginning with the insurrection of Owen Glyndwr, was a period of great disturbance in Wales and any general progress in agriculture was impossible. In the sixteenth century, enclosures became common and gardening began to receive serious attention.

With the conditions that obtained in Wales up to the sixteenth century, it was more difficult to effect any general improvement in stock even than in the land. Under the early Welsh system of tenure not only did the herds and flocks of the *tref* roam over a common pasture, but the value of every kind of animal was fixed by law. Even when these standard values ceased to be applicable, the general level of values remained so low until the sixteenth century that, throughout the medieval period there was hardly room for differentiation between a good and a bad beast. The value of stock in Anglesey at the beginning of the fourteenth century is shown in the Aberffraw assessment given on a previous page. It will be observed that the relative value of stock is much lower than that of corn, a cow only being worth 10d. more than a *crannoc* (eight bushels) of wheat. But prices of both stock and corn no doubt varied in different parts of the country and fluctuated in the same district from period to period. Murrain frequently broke out and the extent of the loss in the stock is reflected in the high prices that followed. Apart from great mortality from disease, stock-breeding was severely checked by the absence of winter keep.

Welsh cattle generally were small and of many colours, a description that in the main applied to them up to the eighteenth century. But though little had been done by way of improvement up to then, there are indications long before of particular features in cattle being appreciated, and of preference being shown for cattle that possessed them. *A'i flew yn glyd fal yn glôg* is, for example, the manner of a fifteenth century poet to express his liking for a

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[18] Rees, *South Wales and the March*, p. 187.
[19] Rowlands, *Idea agriculturae* (1764).
[20] Rees, *op. cit.*, p. 196.

bull's good coat. The bull of his fancy was a red one. But there was no particular incentive to improvement until a regular trade in cattle began. Even with that incentive, the means were largely lacking until the land was managed on a different system. By the seventeenth century the Welsh cattle trade had reached extensive proportions. A considerable trade in dairy produce was carried on in parts of Wales early in the fourteenth century. In a particular case in Glamorgan it is recorded that 130 stone of cheese and 18 stone of butter were sold in 1316 from the manor herd of 20 cows.[21] This gives perhaps some indication of the productive capacity of the cows of the period.

The stock of the medieval Welshman consisted of cattle, sheep, goats, swine and horses, but cattle were generally his most important possession, not only as regards relative value but also very often numerically. Sheep breeding on an extensive scale did not become a special feature of Welsh agriculture until the sixteenth century, although in particular cases large flocks were in existence in the fourteenth century and even earlier. These mainly belonged to the Cistercian abbeys. It is recorded that in 1291 the Abbey of Neath had a flock of 4,204 sheep, of which 1,296 were breeding ewes, and Tintern Abbey had a flock of 2,364.[22] The sheep of the period were small and contained a large proportion of mixed colours. The wool weighed about a pound per fleece and even less and although it is clear that there was considerable trade in Welsh wool in the fourteenth century some of it was of very inferior quality. A record of 1341 concerning South Wales relates to a " licence for 120 sacks of wool to be purveyed to Wales where the wools are coarse and of little value, so that for their poorness they are not numbered among the wools of any sort of the realm of England nor contained in the grant of wools to the King in the last Parliament."[23] It was for the wool rather than for the mutton that sheep were mainly kept, good wool being worth up to 4s. a stone. Flocks of any size consisted as in later times of ewes, wethers, two-year-olds, yearlings and lambs. Mortality from murrain, rot and scab was very high and the proportion of worthless sheep in the flock at the time of stock-taking on some of the Welsh manors might considerably exceed one-third of the whole.[24] For scab, a mixture of hog's grease and tar appears to have been a common treatment.

It may be said that although it had features of great interest, there was little real development in Welsh agriculture generally before the sixteenth century and no striking progress till the eighteenth. Long before then, however, it was passing out of the self-sufficing stage in which it had remained for many centuries.

We see in the establishment in the fourteenth century of regular markets and fairs for stock and produce, not merely a means of controlling trade for purposes of revenue, but evidence that conditions had arisen under which there was already a demand for surplus produce. It is true that the surplus amounted to very little, and that there was none at all in places, but it is in this new idea of a surplus beyond the wants of the producer himself and the demand for it from a growing population, that lies the beginning of the great agricultural development which, in Wales as in England, was so marked a feature of the latter half of the eighteenth century.

THE HUMAN SIDE OF THE FARMING BUSINESS.

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For many years now constant and vigorous efforts have been made to discover the principles underlying farming practices and to solve the scientific problems which confront the application of new practices and methods of raising crops or stock. The physical and chemical properties of soils, together with their bacteriological content have been studied by scientific methods with good results. Studies of the structure of plants, their methods of feeding and foods, and principles of breeding have almost revolutionised knowledge of the industry on its botanical side. While in animal husbandry, the practical efforts of enterprising breeders, together with the scientific study of the chemistry of foods, and the later studies of physiology, bio-chemistry and the principles of heredity, are so changing the types and the productivity of farm stock, that many farmers of seventy years ago would now scarcely be able to "believe their eyes." It is strange, but true, that the main part of the improvements in live-stock, such as arrival at early maturity, and increase in milk yield, has been the work of practical breeders rather than that of scientists. They were assisted by scientists, chiefly in the economy of feeding, but the newer scientific work in animal husbandry is scarcely old enough to have had any great effect on the industry.

21 Rees, *op. cit.*, p. 195.
22 Ib., p. 195.
23 Ib., p. 197, *note.*
24 Ib. p. 297, *note.*
24 Ib., p. 297, *note.*

It does, however, hold out great promise of future improvements and economies. But if one looks at actual farming practices, and their changes, it is striking to note that the practical and the scientific work which is causing the biggest changes is that which is concerned with living things, whether plants or animals.

This being the case, it is strange that the most important of the living things on the farm, the farmers and their families, the workers and their families, and the conditions of economic and human success for them have never been studied. For after all, the success of the farming enterprise as a whole is more dependent upon the human than upon any other element in the organisation. This element supplies intelligence and creative energy. It eventually controls, combines, organises all the other elements in so far as current knowledge and capacity enable it to do so. The scientists may provide all the information on the control or organisation of soils, plants, and animals and the enemies of these, which all their vast equipment provides, but the only channel for applying their knowledge to actual farming practices is that of the minds of the persons on the farm.

But scientific methods of study have recently been applied to other aspects of farming besides the physical and biological. The whole field of the "economic" relationships of the farming industry is now being studied by methods which may fairly be described as "scientific." The financial relationships between the farm and the community, as in markets and prices; the financial relationships between branches of a farming enterprise, as between crops and livestock of different kinds; and the costs of producing different crops and stock products, are special aspects which have been so studied. Economic studies, however, have shown that the financial problems of the farm cannot be solved if investigation is limited to economic relationships of different branches of farming, or even to the direct relationship between the farm and the community through the markets.

Different types and different sizes of farms, different methods of internal organisation of farm work, different forms of organisation between farms, and different forms of organisation between farm and community have been studied for the discovery of their economic results or their economic possibilities. Knowledge in this field is growing rapidly. There remains, however, a whole world of human activities and relationships (all of which have some bearing on the human results of farming and farm organisation, and most of which have such a bearing which is direct and immediate), which have never been subjects of methodical study.

Amongst such subjects are: The age and physical quality of the farming population in relation to efficiency in manual work and its organisation and direction on the farm; the relation of the activities of women to success of the farming enterprise—especially in areas in which small farms prevail; the relation of the outlying farm to the mental and moral qualities of the farm population and its effect on agricultural progress; and the relation between village social organisation and migration of agricultural population and its effect on farm organisation and efficiency. These are examples only, and the list is intended to be indicative rather than exhaustive. These subjects are all primarily human or social; but there are others in which economic considerations are bound up with human desires and feelings. In the case of the controversy of the large *versus* the small farm, for instance, no judgment can ever be based on pure economic considerations alone. One type may support the larger number of families, the other provide the larger average income per family, one a larger output per acre, the other the larger output per person engaged, but these results have to be interpreted in terms not only of quantity of population, produce and income, but also in quality of population and in terms of human aspirations and happiness.

On these and similar subjects connected with the human side of farming, desultory discussions are carried on from time to time. The efficiency of farm labour is frequently discussed, especially when there is any organised movement for control of conditions of employment. Sometimes, this discussion drifts into the sphere of physiological facts, as in the case of nutrition; but more frequently efficiency or inefficiency is attributed entirely to moral factors, especially goodwill. Yet physical, mental and moral factors, as well as some of an economic or social character, produce the total result which is seen. These factors can be separated, analysed, and even to some extent quantitatively measured if the right methods are used. Also the type of education needed or desired by the farm population, whether farmers or workers, is frequently discussed, often with a political bias or with preconceived notions. Yet it would not be impossible to get fairly accurate knowledge of the influence of different types of education on success in farming and on agricultural progress.

On all the human side of farming knowledge and thought is in the state in which knowledge of soils and crops existed about the year 1830. Everyone has some experience, many persons have thoughts and ideas. Experiences are conflicting, and some ideas "work" while others are useless; and while some thoughts are regarded as practical others are regarded as dangerous. But as to

reasons why experiences are conflicting, or why some ideas "work" when others do not, "neither you, nor I, nor nobody knows." We can only discover by methodical and careful investigation. But almost certainly someone will say that exact knowledge on such human subjects cannot be obtained, and that these problems cannot be investigated by scientific methods. It is very unfortunate for human knowledge and human thinking in general that there is a tendency to believe there is something strange and wonderful about the methods of scientific investigation, and to regard the investigator as a sort of wizard. For, usually, scientific investigation is only common sense methodically applied. And no one would deny that human problems could be solved by organised common sense. Scientific investigation is merely a collection, co-ordination, comparison and analysis of experiences. The chief difference between the scientist and the ordinary person who observes and thinks within his own orbit is that the former collects many experiences and takes pains to note the circumstances in which different varieties are found. There are other differences, and some scientists have implements, mental and material, which other people cannot use; but methods more or less similar to those which solved soil problems will solve some of the human problems in the industry.

Even when no final solution of human problems can be found by scientific methods some factors in a situation can be isolated and understood. For instance, in the case of the consideration of efficiency of farm workers, one possible cause of variations is in the age of the persons concerned. When physical energy is the chief factor in efficiency the best working-age is that between 20 and 55 years, or the higher figure may be somewhat reduced. Taking this age-period, it can be shown that there is a lower level of physical capacity amongst men engaged in agriculture than amongst those engaged in other industries.

The following comparison is for England and Wales, but it is hoped that at some time a similar comparison may be made for Wales only.*

Proportion of Males of Various Ages.
(Per cent. of total engaged or employed)

	10 & under 20 years.	20 & under 55 years.	Over 55 years.
All occupied in Agriculture	17.6	61.6	20.8
Employees in Agriculture	22.7	58.8	18.5
All occupied in Mining and Quarrying	18.1	72.8	9.1

	Proportion of Males of Various Ages. (Per cent. of total engaged or employed)		
	10 & under 20 years.	20 & under 55 years.	Over 55 years.
All occupied in Metal Industries ...	16.4	73.3	10.3
In all occupations, excluding Agriculture	15.8	72.9	11.3

Here it is clear that from the point of view of physical capacity of workers, agriculture is in a poor condition when compared with other industries. Still, it has to be remembered that, in some branches of farm work, knowledge and experience are more important than maximum physical energy. This is shown quite clearly in a comparison of the age-levels of shepherds, horsemen, and all employees (including shepherds and horsemen) in the industry.

	Proportion of Males of Various Ages. (Per cent. of Total.)		
Age.	All Male employees.	Shepherds.	Horsemen.
10 and under 15	4.0	1.7	1.9
15—20	18.0	8.1	20.1
10—25	11.1	8.1	19.3
25—35	18.2	17.5	22.2
35—45	15.4	21.2	16.1
45—55	14.1	21.0	12.4
55—65	10.9	14.3	5.9
65—75	6.2	6.8	1.8
75 and upwards	1.2	1.0	0.2

There are many points in these figures which there is not space to discuss, but in the case of horsemen, the concentration between 15 and 45 years, and in the case of shepherds, the concentration between 25 and 65 years is remarkable. These distributions indicate the extent to which the ability to move quickly in one case, and experience and judgment in the other, are required of workers.

Again it is frequently said that the present generation of farm workers is less efficient than its forerunners. This claim that the past generation was better than the present is at least as ancient as Plato, and too much attention should not be paid to it. But it is

* The comparison is based on the census of 1911, as the complete results for 1921 are not available.

worth while seeing what has happened as regards age in relation to the physical capacity of the class of farm workers.

Age.	*Proportion of Farm Workers of Various Ages.* (Per cent. of total.) 1891.	1901.	1911.
10 and under 15 years	8.5	6.1	4.0
15	18.8	17.8	18.0
20	11.8	11.2	11.1
Total under 25	39.1	35.1	33.1
25	17.0	16.9	18.2
35	13.2	15.9	15.4
Total 25—45	30.2	32.8	33.6
45	12.1	13.0	14.1
55	10.3	10.6	10.9
Total 45—65	22.4	23.6	25.0
Over 65	8.3	8.5	7.3

The changes have not been great, except as regards the employment of boys which was reduced under the Education Act of 1902, but such as they were they indicated that in physical capacity as determined by age, there was some improvement in the class of farm workers. This is especially important in the group between 25 and 45 years. Information on other aspects of the problem of efficiency of farm workers could be given; but this is not the time for a discussion of a single problem, and this instance of one set of human facts has been used only as an example.

Such facts do not settle problems of efficiency of farm labour, but surely they are worth having and they help to limit the actual problem. On all the problems which have been mentioned, information can be obtained which throws light on their causes and on methods of solution. But while we are proud of the achievements of agricultural science in the physical and biological spheres, we cannot be content until we have tested the utility of the application of methodical investigation to the human problems connected with farm organisation and the life of agricultural communities. And it is probable that we shall not reap the full fruits of the scientific study of agriculture until we are able to improve the human

material upon the farms and thus provide a better channel between the laboratory and the fields on which crops are grown and stock is fed. The creative synthesis of economic and other scientific knowledge in practical forms of organisation will only become possible through knowledge of human and social facts gained either by trial and error or by sociological analysis.

SOME ASPECTS OF THE AGRICULTURAL CONDITIONS IN CARDIGANSHIRE IN THE NINETEENTH CENTURY.

By Richard Phillips, M.Sc.,

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An interesting glimpse of agricultural conditions in West Wales during the period 1823-1894 is afforded by some old account books, or ledgers, which the writer of this article was fortunate enough to secure. They refer to a 200 acre farm in the Wyre Valley District of Mid-Cardiganshire. This farm lies at an elevation of 500—600 feet on the West Wales coastal plateau. The soil is largely boulder clay drift, hence the farm has been extensively drained.

Practically the whole of the draining and fencing has been done since 1823. The records show that the drainage scheme was at its height in 1841, when 318 perches of 8 yards were cut. The landlord paid for the cutting, and the tenant did the filling and closing of the drains; this was the old Cardiganshire custom. Up to 1855 the rent of this farm was £55 per annum, but with a change of landlords and an improvement in buildings, the rent was increased to twice that amount, a figure at which it still remains. The farm is fairly representative of the district, so that it is possible to claim that the records indicate the agricultural conditions of a large section of mid-Cardiganshire throughout the greater part of the nineteenth century.

The earliest records show that in addition to the farmer's own family, two male servants, two female servants, and one or two hired farm labourers were kept on this holding. The servants, as distinguished from the labourers, were always housed and fed by the farmer, whereas the labourer lived on his cottage holding of five to twelve acres, and received two meals per day in winter and three meals in summer, in addition to his wages.

The economic position of the farm labourer in the "sixties" was not an enviable one, if the following financial statements are typical:

1861. *Receipts.*	£ s. d.	*Expenditure.*	£ s. d.
213 days at 10d. ...	8 17 6	Rent of Cottage Holding	9 0 0
Hedging 20 per @ 5d. ...	0 8 4	12 bushels Barley @ 5s.	3 0 0
Do. 21 per. @ 1s. 6d. ...	1 11 6	Hay, 4½ cwts.	0 10 0
2 Sheep	0 10 0	Balance from 1860 ...	5 11 2
	£11 17 4		£18 1 2
		Debit Balance on 1861 ...	£6 3 10
1862.			
189 days @ 10d. ...	7 17 6	Rent	9 0 0
Hedging 52 per. @ 6d. ...	1 6 0	Corn	1 0 0
Hedges	1 9 2	Balance from 1861 ...	6 3 10
	£10 12 8		£16 3 10
		Debit Balance on 1862 ...	£5 11 2

Unfortunately the labourer's receipts from his own holding are not available, but these would be comparatively small in relation to his wages, and might consist of a few sheep and two yearling cattle. The labourer's apparent loss of liberty was not relieved until his grown up children had begun to earn small wages at the neighbouring farms. In the course of time the collective efforts of the children secured for their parents freedom from debt, and eventually a self-contained small holding of 40 to 60 acres. The farm servant was more independent, because the bulk of his wages were paid to him at the end of the year (November 12th), and he had freedom then to go elsewhere if he so desired. Sentiment, and the fact that his service was in greater demand than that of the labourer, held him as a rule to his own locality. It was not until the depression of the "eighties" and "nineties" that labourers and servants sought employment in the industrial districts of South Wales.

The relation of farm wages to the prices of farm produce is of great interest. There was a gradual rise in the wages of the agricultural worker throughout the whole course of the nineteenth century, but the farmer was not compensated by any corresponding increase in the price of corn and dairy produce. Corn reached its maximum price in 1855-56, and in those years labourers' wages were increased from 9d. to 1s. per day.

TABLE II.

AVERAGES OF FARM SERVANTS' WAGES AND PRICES OF FARM PRODUCTS.

	Men Serv. (Head Men).	*Maid Serv. (Head Maid)*	*Wheat, per Bush.*	*Barley, per Bush.*	*Butter, per Lb.*	*Cheese (Skim M'k), per Lb.*
	£ s. d.	£ s. d.	s. d.	s. d.	s. d.	s. d.
1821—30	5 0 0	2 0 0	—	4 0	0 11	0 3½
1831—40	6 11 0	2 13 6	7 0	4 6	0 10½	0 4
1841—50	—	2 5 0	6 6	4 3	—	0 4
1851—60	8 16 0	6 7 6	7 6	4 6	0 11½	0 3½
1871—80	20 0 0	—	—	—	1 3	0 3½
1881—90	16 0 0	11 7 0	—	4 0	0 11	0 3½
1891—95	20 17 6	12 18 0	—	4 3	1 1	0 3

The farmer was forced therefore, either to reduce his labour bill or to change his system of farming. Pastoral farming became the rule, and arable cultivation was reduced to a point sufficient to maintain the breeding stock and young animals over the winter. The extra pasture thus made available during summer was used for sheep, which hitherto had been grazed on the hills. The farmer was better off for the change, because whereas farm produce maintained a more or less constant price (*e.g.*, butter and cheese, Table II) the price of stock at this time showed an upward trend.

Marketing.

BUTTER. For the greater part of the past century the butter produced during the summer and autumn months was put into casks or tubs and sold in the autumn and winter. The casks were made by local coopers and weighed about 12 to 14 lbs. when empty and 120 to 160 lbs. when full, small casks weighed about 60 to 100 lbs. It was usually reckoned that a cow should produce sufficient butter to fill a cask and to rear her own calf. In 1841, 762 lbs. of butter was sold at 10d. per lb. and another 718 lbs. at 9½d. per lb., making a total of £59 4s. 6d., or an average gross return of £6 per cow for each of the ten cows kept. The butter was usually disposed of to the local inhabitants of Aberystwyth and to the North Cardiganshire lead miners. The surplus was sold to the South Wales merchants through the medium of local higglers. These men took the produce in their carts to various towns in South Wales, of which Merthyr was the most important. With the improved conditions of the local markets and the keener demand for fresh butter, the old system was abandoned in favour of "pound butter," which is still the common practice in the district.

CHEESE. While the demand for cask butter remained, and after the calves had been reared beyond the milk stage, the farmer's wife

directed her attention to the making of skim-milk cheese. It is true that this variety of cheese remained after the cask butter had become less popular, but both are by now things of the past, apart from small quantities made for household purposes.

It is interesting to note that whereas the farm labourers purchased small quantities of cheese, during the winter months more especially, there are only a few entries to show the purchase of butter at the same time. The fact that a cow or two were kept on the holding may have been one reason for this, but many of the older generation remember the time when butter was scarce. It is to be feared that many suffered from want, and that bread and cheese, and not bread and butter and cheese was the commoners' fare.

CORN. There is practically no corn sold from the farms of this district at the present time, but in the past corn, chiefly in the form of barley and wheat, was sold in large quantities. The acreage under these two crops had been reduced from 87 per 1,000 acres in 1867, to 48 per 1,000 acres in 1920, and for the same dates the acreage under oats had increased from 117 to 127 per 1,000 acres* Wheat was disposed of at the corn market in Aberystwyth, either in fairly large quantities to merchants, or else in small lots to cottagers and the lead miners. As wheat bread was considered a luxury, the cottagers were for the most part content with barley bread. Gwallter Mechain at the beginning of the century states that "along with potatoes barley bread constitutes the chief sustenance of the poor."

The records show sales of barley to local cottagers and also to the hill cottagers in the more exposed districts ten to twenty miles away. The farmers situated nearer the coast-line and within the region of the famous barley belt of Cardiganshire were able to grow better quality barley for malting purposes; they disposed of it to the Llanon and Aberystwyth breweries.

When the demand for bread corn disappeared ,there still remained the demand for seed wheat and seed oats and to a less extent for seed barley, grown by the lowland farmers to supply the needs of those working under less favourable conditions. From 1880—1894 there are entries of increasing sales of Ceirch Llwyd or Welsh Strigosa to the upland farmers, and this eventually became a good source of income to the grower.

FARM STOCK. As with dairy produce and corn, so with farm stock, there have been changes in methods of rearing and marketing. At one time the countryside was enlivened by a great many village fairs

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* Board of Agriculture Returns.

held throughout the year, and these were as familiar and as common as the competitive meeting and the Eisteddfodau of the present day. Up to the " seventies " there were at least ten villages within a radius of twenty miles in which one or more fairs were held annually on fixed dates. Most of these have now disappeared and their places taken by marts nearer the railway stations; the coming of the railways meant the ruin of these countryside festivities.

At one time the cattle were the native Welsh breed and the dscriptive names of the cows indicate that the colour was not uniformly black, but varied from red, brindle and dun, to black, black and white, and black and grey with the dorsal white line marking. Although it is difficult to establish a fixed date, it may be stated with a fair amount of certainty that the introduction of Shorthorn bulls for crossing purposes started about the " seventies," and had become a common practice about the " nineties," with the result that there are at present only a few herds of the native breed remaining.

Up to the " eighties " the store cattle were not disposed of until they attained the age of 2½ to 3 years, and during the second summer of their lives these stores were mountain grazed. The records indicate that for this district the Lledrod Fair (October 7th) was the most important one for the store cattle or Welsh Runts sales. In the absence of a railway the cattle were driven to Leicester, Essex and Kent pastures, and fattened for the London market. In order to be able to stand road travelling they were shod with " ciws " or " ques " (a two section iron shoe with three nails in each), by the local smiths in paddocks close to the fair ground. Since the advent of the railway in 1865 and the demand for earlier maturing beasts, store cattle are now sold at the earlier age of 1½ to 2 years, at the early spring marts and to a lesser extent at the autumn marts. Dairy cows on the other hand were at the time to which the books refer chiefly sold at various spring sales of which the most important was the Llanbadarn Fair.

Working horses and colts were sold at the spring fairs of Tregaron (March 17th) and Lampeter (Dalis Fairs, May 5th—7th). These fairs are important horse fairs at the present day, but the Aberystwyth Fairs (May 4th and September 17th) do not figure in the farm records, and have been established since. Younger horses such as suckers, yearlings, and two-year-olds, of the cob and mountain pony type chiefly, were disposed of at the Ffair Rhos (September 25th) and Lledrod Fair (October 7th). In many instances farmers in more sheltered districts purchased the most forward of these and disposed of them again at the following spring sales. The Lledrod

fair has disappeared, but the Ffair Rhos, although less prominent than hitherto, is still frequented.

SHEEP. Apart from the sale of a few fat sheep (ewes and wethers) to local butchers, the bulk of the sheep were sold as stores in early autumn at the Brecon fairs. There are a few entries to show that the farmers drove their own flocks to Brecon. Generally they disposed of their store stock at home to local sheep dealers, who drove the combined flocks from several farms to the Brecon fairs. About the "nineties" the practice was discontinued on many farms and fat lambs in continued numbers were produced to supply "the summer loungers at Aberystwyth with juicy meat." With the adoption of this practice the system of sheep management was altered. Whereas previously it was the custom to send the flock to the hills for summer grazing, now it was kept on the lowland. This accounts for the fact that the summer sheep population of the low-lying districts increased from 90 per 1,000 acres in 1867 to 437 per 1,000 acres in 1900, and for the same years decreased on the uplands from 397 to 195 per 1,000 acres.*

PIGS. Pigs were usually disposed of either as weaners, fat pigs (sold in autumn and winter) and as stores at an earlier period. The piglings were sold to local cottagers at home, or else at the Aberystwyth and Tregaron Fairs. There is one record to show that piglings were taken as far as Lampeter, and one rare instance of pigling sales at "Ffair Gwyl Ifan yr Haf" on July 2nd, 1888. In this case the weaners were sold to the Ysbytty Ystwyth Cottagers. Store pigs were sold at the local fairs and driven elsewhere to be fattened. Fat pigs, on the other hand, were usually sold at home to local butchers or else to the travelling higglers who slaughtered the pigs at their own homes in Cardiganshire, and then took the carcases in their carts all the way to Merthyr.

It should be mentioned that Merthyr at this time had become a very important market centre for agricultural produce. It is referred to several times in the farm records we are considering. There was also an idea amongst the peasant class that Merthyr was a wide district (gwlad) rather than a town (tref). On the other hand, Bristol is frequently referred to in the older agricultural literature in Cardiganshire as the distant market centre.

Even after the coming of the railway the higglers carried on their business, but from the "eighties" onwards the foreign competition in bacon practically destroyed the sale of home-cured Welsh bacon in the South Wales districts.

* Ministry of Agriculture returns.

Conclusion.

In conclusion, a reference may be made to the general social changes which have taken place in the period and area covered by these records. The decline of arable farming and the depopulation of the countryside have been accompanied by a great increase of stock, and a higher standard of life amongst the rural population. The change most to be regretted is the disappearance of the village artisan and the cessation of rural industries. In the district referred to in this article, there were at one time, several coopers, weavers, cloggers, basket makers and fullers (panwyr). There were also the travelling tailors and saddlers who were wont to bring merriment or introduce musical talent to the quiet homestead hearth. The area is now populated by people interested in agriculture only, and the absence of the tonic effect of other callings is a considerable loss to the social life of the district.

"NOD BEUNO."

By R. Alun Roberts, B.Sc.,
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Considerable interest has recently been awakened in the mark known as "Nod Beuno" or "Beuno's Mark," a slit or dent occasionally met with in the ears of Welsh cattle at birth.[1] Though unknown to many experienced breeders, it is fairly persistent in the herds of others, particularly in Carnarvonshire. Less than a generation ago it was known in Carmarthenshire and Pembrokeshire, but appears to be very rarely met with there now. The great reduction in the numbers of pure bred Welsh cattle which has occurred in South Wales within the last twenty or thirty years doubtless accounts at least partly for this.

The mark derives its name from the custom of handing over the animals that bore it to the Church of St. Beuno at Clynnog in Carnarvonshire as a charge rightly due to that institution.

Historical.

Little is known of the early history of the Monastery at Clynnog. It is conjectured that it was established in the sixth century, and that the brotherhood was of a simple order, such as the Colidei of

1 The mark is mentioned in a prospectus recently issued by a Committee interested in the restoration of St. Beuno's Church, Clynnog, Carnarvonshire.
A note was also published in "Y Genedl Cymreig," Carnarvon, Saturday, April 19th, 1924, soliciting information as to the prevalence or otherwise of the mark in present day stock.

Bardsey, Puffin, and Bangor-on-Dee. At a much later date, it is *maintained, the Cistercians or White Friars established themselves here, but were dissolved sometime before the end of the thirteenth* century. It retained its collegiate functions until the time of Henry VIII, having at that time five portionists, as shown by the assessment of Pope Nicholas in 1291.[2] The living now belongs to Jesus College, Oxford, and the Vicar is nominated by the Bishop of Bangor. Be this as it may, the old monastic records of Clynnog, known as "Y Diboeth" (unburnt), so called because they were saved from the burning when the building was once gutted by fire, are completely lost, and all other outside records are very scanty. In the cover was set a stone (Maen y Diboeth) and the script was probably sacrificed lest it should incriminate him who looted the stone.

It is, however, certain that until comparatively recent times, sheep and young cattle which bore the mark were brought to the Church of Clynnog as though they were sacred animals. They were offered for sale, and the proceeds were lodged in "Cyff Beuno" within the Church.[3] There is reason to believe that half of the proceeds of the sale were assigned to the poor of the parish, and the other half of the maintenance of the church building. There is no exact record of the moneys derived from this source in any one year, as other funds were similarly deposited in "Cyff Beuno." There is, however, a record of a total of £15 8s. 3d. obtained from various sources resting in the chest on December 3rd, 1688.[4] Within the memory of folks living in 1863, when Eben Fardd wrote his "Cyff Beuno," many sums were voluntarily offered in respect of the thriving of their stock, although the practice of surrendering beasts with "Nod Beuno" had been long discontinued. No specific mention of revenue from this source is made in the survey of church emoluments known as "Valor Ecclessiasticus" in the reign of Henry VIII.

Quoting from an article by the Rev. J. E. de Hirsch Davies,[5] we find a lengthy reference to a specific instance of the practice of

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2 *Archaeologia Cambrensis,* "Arvonia Mediaeva," p. 251.

3 "Cyff Beuno" is an old chest, still to be seen within the Church, hollowed out of one piece of timber. The top piece is sawn off in the form of a cover and has a slit in it whereby money offerings could be introduced into the chest. An iron bolt runs the length of the chest and plays through iron clasps, bearing at these points three locks, the keys of which were variously kept by the incumbent and two wardens and could only be opened in their joint presence. *Vide* "Cyff Beuno," by Eben Fardd, published by Robert Isaac Jones, Tremadoc, 1863.

4 *Archaeologia Cambrensis,* Vol. III, p. 256.

5 *History and Antiquities of Clynnog,* Rev. J. E. de Hirsch Davies, formerly Vicar of Clynnog. *North Wales Chronicle,* Bangor, Friday, February 7, 1913. 3rd article.

offering bullocks to the saint at Clynnog as witnessed by Lelland in his tour in Wales in 1589: "Upon Monday in Whitsun week there was a young man that had been carried thither the night before . . . . I followed him into the close, and the young man drove the bullock before him, being about a year old, and as the bullock did enter through a little porch into the churchyard, the young man spake aloud—'The Half to God and to Beuno.' This was in the Parish of Clynnog in the year of our Lord 1589. There be many other things in the county very gross and superstitious as that the people are of opinion that Beuno, his cattle will prosper marvellous well, which maketh the people more desirous to buy them." (This is significant in view of the persistence of the mark to the present day).

Elsewhere[6] we find the following, which seems to be in keeping with the above:—"They were formerly used to besprinkle cattle with an ew bough and the water of Ffynon Beyno: ffynon Veino yn agos i'r Eglwys." The sprinkling was presumably meant as a blessing.

It is interesting to speculate why such animals should be brought to Clynnog. The existence of a similar mark in Jersey cattle, noted later, suggests at least the possibility that the Monks had introduced from the South, or more probably France, cattle bearing the mark, and claimed as a right those of their descendants in which it appeared. The practice of surrendering beasts to Beuno's Church probably lapsed towards the end of the eighteenth century. A strong contributing cause would doubtless be the Methodist Movement which set in from 1742 and became a practical force in the country twenty or thirty years later. There are certainly no records of money being obtained from this source at Clynnog during the nineteenth century.[7]

The mark still persists among cattle, but I have met no shepherd in Snowdonia who had heard of its existence in sheep. As practically all lambs there are ear-marked any abnormality of this kind could not possibly escape notice, and this points to its having died out, if ever it existed. Even in cattle it is necessary to be particularly careful before accepting any slit or dent in the ear as being of the "Nod Beuno" type unless it is observed at birth. On some upland

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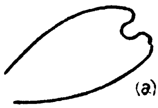
[6] *Peniarth MS.* 251, under "Gwyddelwern."

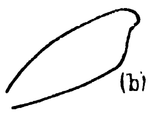
[7] Through the courtesy of A. Ivor Pryce, Esq., M.A., Diocesan Registrar for the Bangor Diocese, I have been given access to the periodical inventories of Church property, revenue, etc., submitted by the incumbents of the living to the Bishop's Chaplain. Scrutiny of these as far back as the early years of the nineteenth century (the earliest available) fails to reveal any revenue from beasts bearing Beuno's mark.

farms young cattle are still earmarked before they are turned for summer to the upland grazing, and worrying by dogs and other accidents also often cause cuts in the ear.

Before mentioning specific instances of the mark among pedigree Welsh Black Cattle I would make the following observations upon the remarks I have gleaned from among peope who had for some time past been acquainted with it:—

There is no uniformity in the nature and outline of the mark. Historians generally refer to it as a "hollt" (slit). Farmers of experience give it as a "cnoad" (cavity as of a bitten piece), and not a "toriad" (cut), *i.e.*, it is rounded and not pointed. It is generally of this kind (*a*), though the form (*b*) is also met with.


(a)


(b)

It generally occurs on the two ears, though it is not necessarily equally pronounced on both.

It is said that the mark is met with in calves, neither of whose parents bears it, but in view of the conclusion arrived at by Lush, that it is due to a single dominant factor, this statement requires confirmation. If Lush's theory is right, and the mark investigated by him is the same as "Nod Beuno," it would be impossible for a calf to bear it unless one of the parents also had it. The fact that it varies in intensity and may almost be un-noticeable to a casual observer suggests the possibility of its not having been noticed, though present in animals whose offspring clearly showed it. Mr. Griffiths, of Glasfryn Fawr, Chwilog, the breeder of the dam mentioned below, says that the mark was common in his herd long before any stock were entered in the Herd Book, and that a cow [Glasfryn Mary (2600)] still there bears calves all of which have the mark. This, though not conclusive, supports Lush's conclusion that the occurrence of "Nod Beuno" is due to a dominant factor, and emphasises the need for more information before it can be accepted that normal parents may produce calves with the mark. No particular merit is claimed for cattle bearing the mark, though some breeders retain them for the herd with particular care. In Carnarvonshire, at any rate, no instances have been brought to notice of its occurrence among cattle other than Welsh Blacks, but as this breed practically monopolises the county, this is not proof that it does not affect other breeds.

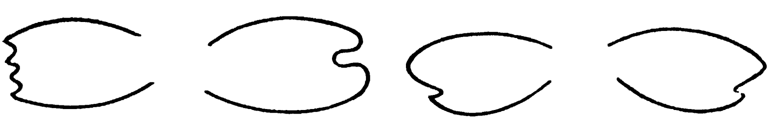
A similar mark has been recently worked on by Lush in two Jersey Bulls, Nos. 109548 and 96298 in the American Herd Book.[8] His description is:—

"When viewed from the front the ears of Gamboge's Raleigh appear to have a piece neatly clipped out of them. The outer end of the notch merges rather gradually into the natural curve of the ear, while the other end of the notch makes an acute angle with the ear's lower edge, leaving a sharp corner projecting downward and outward. Close examination reveals the fact that the projection is really doubled in both ears, although more distinctly in the left than in the right. The doubling occurs as a front and rear projection and the groove between them is about half-an-inch deep in the case of the left ear and about one-quarter-of-an-inch in the case of the right."

Lush maintains that the manner of inheritance indicates that it is due to a single dominant factor, independent of sex. It will be noted that the above is in agreement with the appearance of "Nod Beuno" but for the acuteness of the notch, and its position. In the Jersey cattle examined, the notch was underneath and not at the end of the ear. In a letter recently received, Mr. Lush states that the existence of a similar notch in the ears of Ayrshire cattle has been reported. In that breed the "notch seems to be at the end of the ear."

Incidence of "Nod Beuno" in Pedigree Welsh Black Cattle.

The mark is fairly common in some pedigree herds of Welsh Black Cattle. Two pedigree beasts, one a two-year-old bullock, son of Glasfryn II (4949), and the other a young heifer calf, a daughter of Tyddyn Rosa, at Wernfawr, Llanbedrog, Carnarvonshire, owned by Mr. R. Rees Thomas, of Penarwel, Llanbedrog, exhibit the mark at present. In both cases it is borne on both ears. It is of an unpronounced acute pattern, and uniform in both ears in the case of the heifer calf; while in the bullock it consists of deep multiple dents in the right ear, and a single pronounced dent in the left. At the time of observation by the writer the bullock was running out on grass and could not be closely approached for detailed observation. Represented diagramatically, however, these instances can be represented thus:—



Right. Left.
Bullock.

Right. Left.
Heifer Calf.

[8] *An Hereditary Notch in the Ears of Jersey Cattle.* J. L. Lush, *Journal of Heredity*, Vol. XIII, No. 1, 1922. Abstract section of this Journal, p. 238.

The descent of each animal has been worked out to the fourth generation, and to that stage the only ancestor common to both animals is Robin Ddu. (518). The writer would be grateful for particulars of the breeding of any animals which have the mark, as it is only by close scrutiny of the occurrence of the mark in the ancestry of those now bearing it, together with observation of its occurrence in their direct descendants, that valuable data can be collected. It would also be particularly interesting to know whether the mark is known in pure bred animals of breeds other than Welsh. The factor is in itself of little economic importance, but its biological significance to the student of Genetics may be very great, and if the mode of its inheritance can be traced, it will form a valuable addition to our present scanty knowledge of the Genetics of domestic animals.

RESEARCH WORK IN ANIMAL BREEDING

AT THE COLLEGE FARM OF THE UNIVERSITY COLLEGE OF NORTH WALES, BANGOR.

By Professor R. G. White, M.Sc.

Two years ago the University College of North Wales received a special Research Grant from the Ministry of Agriculture in aid of investigations on the wool of Welsh Sheep, and Mr. J. A. Fraser Roberts, B.A., B.Sc., was appointed to carry out the work.

In the autumn of 1923 the Ministry decided to enlarge the scope of the wool research, and it was placed under the direction of the Animal Breeding Research Department, Edinburgh. Mr. Roberts thereupon was transferred to Edinburgh, but still, as part of his duties, supervises the work at Bangor, and he has drawn up the following account of the research in progress there. Most of the work deals with Welsh Mountain Sheep, of which a large flock is maintained at the College Farm, and they appear to provide exceptionally good material for Genetical Research.

I. Wool Improvement in Welsh Sheep.

In any scheme for the improvement of the wool of British mountain sheep two considerations must constantly be borne in mind, first that the hardiness of the sheep must not be impaired and secondly, that mutton qualities must not suffer in any way. Hardiness, or the adjustment of the animal to its environment, is particularly important in a mountain breed such as the Welsh, and

might be easily affected; this consideration rules out the possibility of any improvement scheme which involves crossing with finer-woolled lowland breeds. Selection within the breed is therefore the basis of the scheme outlined below. It may be stated at once that extreme variation in wool qualities is to be found in every Welsh flock, the coats of different individuals varying from the coarsest kind to those which are practically as good as Down fleeces. There is therefore ample scope for improvement by selection, should such improvement be found not to affect adversely the other characters of the sheep.

It is necessary to study the fleece from the point of view of the manufacturer, from that of the breeder, and finally from the biological point of view. The manufacturer's requirements are (1) fineness of fibre; (2) absence of kemp and red kemp—(black fibres, which are an objectionable feature of the wool of some other breeds, do not occur in ordinary Welsh sheep).

The breeder desires in the lamb a thick weather-resisting coat, and in the adult a dense, moderately long fleece, free from "lockiness" and with possibly a little "top" to throw off the rain. Many breeders are also of the opinion that kemp is associated with hardiness, though few would be prepared to say exactly what the connection is. If any connection does exist, it seems most likely to be found in the coat of the new-born lamb.

The task of the biologist is to reduce these requirements to biological terms, to see how far the breeders' opinion of a good fleece is really founded upon essential requirements, and how much is mere conjecture, and to attempt to harmonise as far as possible the requirements of breeder and manufacturer; finally to investigate the inheritance of the desired qualities so as to assist the breeder to attain the best type as rapidly and surely as possible.

To ascertain the opinions of breeder and manufacturer the fleece of each sheep of the College pedigree flock has been graded by experts.

The development and structure of the fleece, and of the fibres composing it, have been closely investigated. It was found at the outset that the coats of Welsh lambs at birth fall into three classes, viz.:

(*a*) thick hairy coat all over the body;

(*b*) fine curling wool like that of a Down type of lamb on the shoulders or fore part only, the rest of the body being covered as in (*a*);

(*c*) fine curling wool all over.

Types (*b*) and (*c*) are held to be unsuitable for extreme mountain conditions. The lambs of the pedigree and mountain flocks have been graded according to the type of their coat at birth and it will be possible to follow their further development and to work out any correlation between this and the qualities of the adult fleece.

An examination of adult fleeces shows that the fibres composing them may be separated into five classes:—

(*a*) kemp;
(*b*) red kemp;
(*c*) coarse hair;
(*d*) fine intermediate fibres;
(*e*) fine wool.

Coarse hair is of little importance in Welsh sheep; it is only found in some sheep, and then only in one or two places in the fleece. A Welsh fleece therefore usually consists of fibres of classes (*a*), (*d*), and (*e*) with (*b*) in certain cases. The outstanding problem is undoubtedly the elimination of kemp, which may be defined as short, coarse, brittle fibres showing characteristic breaks along the length. A method has been evolved for the estimation of their proportion of kemp in each fleece, and this is being worked out in the case of each sheep in the pedigree flock.

From a biological point of view the problem is hopeful because kemp and red kemp differ from other fibres in being annual in their growth.

With a knowledge of the following points in the case of a large number of individual sheep, it will be possible to supply an answer to many of the problems raised above:—

(*a*) the manufacturer's opinion;
(*b*) the breeder's opinion;
(*c*) the proportion of kemp;
(*d*) the type of coat at birth, and
(*e*) (in some cases) the mutton qualities of the sheep.

It will also be possible to observe variations from year to year in the same animal, and to test the effects of environment.

While there is no doubt that once convinced as to the type at which to aim, the breeder, following his traditional methods, can secure rapid improvement, the work outlined above will provide basis for genetical study which will, it is hoped, enable him to attain this end more rapidly.

As regards red kemp, which is a very serious defect, there is no doubt that this is associated with a tan face and legs, and with the tan patches on the back of the neck of Welsh lambs. As long as

these are considered desirable features, it will be impossible to eliminate red kemp. In the future, breeders of Welsh sheep will undoubtedly have seriously to consider whether some slight alteration in standards will not be desirable in order to secure rapid and automatic improvement in this respect.

II. Colour Inheritance in Sheep.

The chief aim of the student of the genetics of farm animals must be the gradual analysis, unit by unit, of his material. Each advance makes the next step easier and ultimately, it may be hoped, characters of economic importance may be dealt with in such a way as materially to reinforce the methods of the breeder. The investigation, therefore, of the inheritance of simple characters which have, perhaps, little economic significance is the essential preliminary step after which important practical advances may reasonably be anticipated. It would be impossible to over-emphasise the value of a stock whose constitution was known with respect to, say, six or seven simple Mendelian factors.

Two characters have been selected in the case of the sheep, the inheritance of which might be expected to be comparatively simple. These are (1) black colour as shown in the Black Welsh Mountain breed as contrasted with the white of ordinary Welsh sheep, and (2) the peculiar black and white pattern to which the name of "badger-face" has been given. This is found in a few individuals in many Welsh flocks, individuals of this sort being referred to in some parts of Wales as "defaid Idloes."

An experimental flock of eighty sheep was collected during the autumn of 1923 and all possible matings were made. The results of a single year's breeding do not justify more than tentative conclusions, but there is no doubt that the problem is soluble. The results are summarised in the following table:—

	Lambs.		
	Badger-face.	Black.	White.
1. Badger-faced Ram x badger-faced Ewes gave	12	—	—
2. Badger-faced Ram x white " "	2	—	16
3. White Ram x badger-face " "	6	—	1
4. Black Ram x white " "	—	23	—
5. White Ram x black " "	—	5	2
6. Badger-faced Ram x black " "	1	3	—
7. Black Ram x badger-face " "	—	12	1

An account of this work has been prepared for the Journal of Genetics and is now in the press. It may be stated here that, with certain reservations, the badger-face pattern may be accepted as a

simple recessive character and black colour in this case as a simple dominant.

Recently a sheep showing very unusual markings has been secured, viz., a "reversed" badger-face. In this animal the face is black except for two white stripes, the body is very dark except for the ventral surface, which is light. The sheep shows almost exactly reversed badger-face markings. The Agricultural Department would be very grateful if any breeder who happens to possess a sheep of this sort would give them the chance of acquiring it.

Another interesting investigation concerns the inheritance of colour in crosses of "Spanish" or Piebald sheep with other breeds. It has been stated that crosses of these sheep with any other breed are invariably black. Through the courtesy of several breeders the writer has been enabled to examine flocks where such crosses have been made. Major E. J. W. Platt, who owns one of these flocks of Spanish sheep, is proceeding further with this experiment. This will be another and most interesting chapter in the story of colour inheritance in sheep.

The relation of the black colour of Black Welsh sheep and the black (dark brown) of the Spanish will also be tested; by means of appropriate crosses it will be possible to test whether the colour in the two cases is based upon the same, or upon different Mendelian factors.

III. Congenital Abnormalities.

It is known to every breeder that congenital defects and abnormalities in farm animals are not uncommon and are often accountable for considerable loss. While the nature and mode of inheritance of these defects are often fairly simple from the scientific point of view, the breeder, following his traditional methods, is quite unable to account for their occurrence or to eliminate them from his flocks and herds. There is probably no sphere where animal breeding research work can be of such immediate practical assistance.

Two such abnormalities in sheep are being closely investigated—one a limb defect which causes the death of the lamb and often of the mother at the time of birth, the other the occurrence of eyeless lambs which possibly also exhibit cerebral abnormalities.

It is hoped that the occurrence of any other abnormalities of the kind will be reported and it need hardly be said that in such cases great care is taken that the particular herd or flock concerned cannot be identified from any description which may be published.

IV. In-breeding Experiments.

It is accepted by scientists that in-breeding in itself is not responsible for the beneficial or harmful results which follow this practice. It merely results in animals which are homozygons for a larger number of hereditary factors than were the original stocks; it unmasks the hereditary potentialities of that stock. This is shown clearly by the work carried out in America with rats and guinea pigs. In the former case twenty-five generations were raised by continued brother to sister matings. Certain lines developed defects or became sterile but others prospered, and at the end of the experiment were superior in many respects to the stock with which the experiment started.

Such an experiment with farm animals could not fail to give most interesting data even if the lines were all to die out. A commencement is therefore being made with sheep, the College flock being particularly suitable for this purpose as from the breeding system which has been followed for many years the sheep must already be homozygons in many respects.

There is no doubt that the first step in many experiments in biology in the future will be the production by close in-breeding of stocks which are genetically uniform; from a practical point of view, too, one has only to examine the records of the founders of our modern breeds to realise how vigorously they employed this method.

THE SCIENCE OF GENETICS AND THE STOCK-BREEDER.

By J. A. Fraser Roberts, B.A., B.Sc.,

Research Assistant, Animal Breeding Research Department, University, Edinburgh;

Honorary Lecturer in Genetics, University College, Bangor.

The modern study of heredity dates from the beginning of the present century. During the last twenty-five years a great amount of knowledge has been accumulated about the hereditary processes. This has been linked up at many points with general physiology and it can also be said that to a large extent the biological principles underlying the methods of the practical breeder are capable of explanation. At the present time, when public bodies and private individuals are becoming increasingly interested in the question of how this new knowledge can be applied so as to improve breeding

practice, it is useful to consider what the science of genetics has to offer to the breeder of farm stock.

It is true that up to the present nearly all genetical observation and experimentation has been carried out with small laboratory animals, insects, rats, mice, rabbits, etc., chiefly for reasons of economy, but also because laboratory animals can more easily be kept under standardized conditions, but, as the work has progressed the fact has emerged more and more clearly that the principles of the science are of general application—the processes at work on small animals operate in a precisely similar manner in the case of farm stock. In the first place, therefore, the science of genetics offers to the breeder an explanation of the successes and failures associated with his traditional methods, and enables him to distinguish between essential and non-essential steps. Genetics has a great deal to say upon such subjects as in-breeding, line-breeding, outcrossing, the superiority of first-cross animals, prepotency, "purity," and so on. The breeder with a knowledge of genetical theory can frame a policy with his eyes open and with a full knowledge of the advantages and risks which are bound up with the methods he is pursuing. An authoritative opinion can be pronounced upon some of the traditional beliefs, such as telegony, infection of the male, saturation, maternal impressions and the rest. The breeder is successful in as far as his methods are in harmony with biological principles, and the striking successes attained in the past are evidence of how certainly he has progressed, by methods of trial and error, towards his ideals. Yet a scientific knowledge of the principles upon which are based the methods he is employing will save him much wasted effort, will enable him to omit what is unnecessary and will warn him beforehand when he is attempting the biologically impossible, or when success in attaining a particular end will be neutralised by a setback in asother direction.

The geneticist usually deals not with the animal as a whole, not with an aggregate of characteristics which blend to give the complete individual—he considers not the total effects in a cross between a white Shorthorn bull and Galloway cows, but the individual "characters" of horns *versus* hornlessness, white, blue-grey and black coat colours, etc. His aim is always the analysis of his material unit by unit, and his ultimate ideal is a knowledge of all such units that go to make up the complete animal. In the case of farm stock the characters selected for study have, so far, usually been superficial and not of the first importance to the breeder, but this is only a beginning—ultimately the analysis will include hundreds of units and the breeder will be able to replace rule of thumb methods,

and costly trial and error for certainty just as far as the analysis has progressed. This, then, is the second way in which genetics can reinforce practical methods—it is an ideal and many years must elapse and an immense amount of observation and experimentation be carried out before it can be even partially realised. The main purpose of this work must be to build for another generation, with the certain knowledge that each step makes the next step easier. Here again laboratory work on small animals will be of the greatest value—analogics can constantly be drawn between such material and farm stock and experiments with the latter can be simplified and costly failures avoided by comparisons with the breeding results of small, rapidly reproducing, inexpensive animals. In this work the co-operation of the practical breeder is essential; very little extra trouble is involved in keeping records which, when fitted in with others, will be of great scientific value and will indicate the most profitable direction for further effort.

Finally, the individual results attained during the analysis will often be of practical importance and capable of immediate application. It should be borne in mind that the methods of genetics can be applied not only to characteristics visible to the naked eye or capable of measurement, such as coat colour, the size and form of various organs, or of the whole animal, but also to physiological characteristics, and it is probable that it is here that results of the most immediate practical importance can be attained. For example, resistance to or a predisposition towards various diseases or group of diseases is inherited. In certain parts of the world ordinary cattle cannot be bred owing to their susceptibility to certain diseases whereas the native Brahmin cattle of India (Zebu cattle) are immune. It has been found that by means of crossing followed by selection it is possible to secure strains which combine the disease-resisting qualities of the Zebu with many of the valuable characters of our ordinary breeds. Again the question of fertility is of the greatest importance to breeders. A breeder has frequently all but attained the standards of excellence at which he aimed when his results are rendered valueless by the development of relative or absolute unfertility in his stock. In conjunction with physiology, (the dividing line is in this case as in many others very indefinite) genetics has a great deal to say upon the subject and it would appear to present a series of problems to which the scientist can very readily bring reinforcement to the breeder's methods. Such questions as the inheritance of milk-yield, tendency to lay on fat in the right places, though complicated, are by no means hopeless, and are being extensively studied at the present time.

Another very important subject is the occurrence of monstrosities or animals showing various malformations and abnormalities. This is much more general than is usually realized; the breeder is naturally not anxious to advertise anything so likely to reduce the value of his breeding stock, yet his losses from these causes are often heavy, sometimes involving mother and offspring, and it is almost always the case that pursuing his traditional methods he is quite unable to reduce the number of such animals born. Such cases are often quite simple from a scientific point of view, and there is probably no field where the breeder is more likely to receive immediate practical help from the geneticist.

The breeder is always keenly interested in the proportion of the sexes which occurs in his stock and is often firmly convinced that it varies in response to seasonal differences, feeding, conditions of service and other more or less controlable causes. As yet not much is known from a scientific point of view about the causes underlying variations in the sex-ratio, but knowledge is growing, and it will not be denied that finality in this matter will be of considerable importance even if it were to be negative—which is by no means certain. Sexual abnormalities are not uncommon and may even in some cases be so numerous as to be the cause of appreciable loss—for example, intersexuality in goats or white heifer disease. The scientist is rapidly arriving at an explanation of these phenomena.

Even on the more purely morphological side there are many characters which are at the same time important individually to the breeder and fairly straightforward problems for the geneticist. The fleece of the sheep is an excellent example and even skin and coat colour or horn growth, which are the first questions to which the geneticist usually applies himself, have often some practical value.

Like every other science genetics has its alphabet and a fairly large vocabulary of technical terms. Though this may appear terrifying at first sight to the layman, the subject is not difficult. The main principles of the science are few in number and relatively simple. It is impossible in the space of a short article to explain the methods of genetics; those who are interested are recommended to refer to a series of four articles by Professor Punnett in the Journal of the Ministry of Agriculture (1921), entitled "Research in Animal Breeding," or to the books "Mendelism" by Punnett, and "An Introduction to the Science of Animal Breeding," by Crew. The breeder who interests himself in the science of heredity will undoubtedly find additional interest in his stock and will be able to appreciate the discoveries that are continually being made and to apply them to his problems.

Great activity prevails in the field of genetics both pure and applied, and there will be found in this volume abstracts dealing with current work. In these abstracts the opportunity will be taken to summarise what is known of heredity in each class of farm animals, and in addition papers which add to our knowledge of the principles of the science will be reviewed and work in progress will be noted.

THE NUTRITIVE REQUIREMENTS OF POULTRY.

BY GRIFFITH JONES, B.SC.,

Director of Agriculture for Anglesey.

The question of feeding poultry has engaged the attention of poultry keepers for a long period of years. Probably no other subject has received such constant attention. Yet, to-day, if one were to take the opinion of poultry keepers on a particular feeding question the replies would differ materially. New light and more light is required on the fundamental principles of nutrition, and here there is a wide field before us for experimental work.

Very valuable research work has been carried out on the above subject by the Rowett Institute in conjunction with the three Scottish Colleges of Agriculture, and the results are published in the Scottish Journal of Agriculture in articles prepared by J. B. Orr, M.D., and Mrs. H. Maciver, Board of Agriculture for Scotland. In this short statement it is only intended to deal very briefly with the results obtained.

Of late years, poultry keepers have been advised to supplement their rations with Cod Liver Oil and certain proprietary foodstuffs, on the grounds that the vitamins contained in them promote growth and increase egg production. The work of the Rowett Institute and the three Scottish Agricultural Colleges confines itself to "fat soluble vitamin or vitamin A" and its effect on (*a*) growth, (*b*) laying, and (*c*) hatchability. Cod Liver Oil is used in the experiments as food rich in fat soluble vitamin, and its effect is contrasted with Linseed Oil, which is deficient in fat soluble vitamin. Further, the experiments include control pens fed on basal rations without the inclusion of any oil.

(*a*) GROWTH EXPERIMENTS. In these experiments, the caloric value of Cod Liver Oil was balanced in the control pens by the inclusion of an equal amount of Linseed Oil.

The experiment at Rowett Institute included two pens with six Leghorn chickens. Each pen received a basal ration, which included Maize, Bran, Oatmeal, Fishmeal and Bone Meal in the mash, with Oats and Wheat as grain. Limestone grit and water was supplied *ad lib.* Pen No. 1 had 5.c.c. Cod Liver Oil per bird per day added to the mash, and Pen No. 2 an equal amount of Linseed Oil. The experiment was continued for 90 days, with the following results:—

Pen No. 1 gave average increase per bird per day of 8.6 gramms.
Pen No. 2 gave average increase per bird per day of 10.7 gramms.

A similar experiment conducted with cockerels continued for 50 days gave 13.1 gramms increase with Cod Liver Oil and 12.3 gramms in the Linseed Oil Pen.

At the East of Scotland Agricultural College, two pens, each with 10 Anconas, were experimented on, the basal ration being in principle the same as that used at Rowett Institute. Pen No. 1 received 1.c.c. Cod Liver Oil per bird per day and Pen No. 2 an equal amount of Linseed Oil. The trial was kept up for 230 days, and gave the following results:—

Pen No. 1 gave average increase per bird per day of 5.00 gramms.
Pen No. 2 gave average increase per bird per day of 5.04 gramms.

At the West of Scotland Agricultural College the experiment included three pens, each with 70 White Leghorns, 7 days old at the beginning of the experiment. The basal ration consisted of seeds and cereal grains, with milk for the first 14 days, and thereafter fish meal. Pen No. 1 received 1/5th c.c. Cod Liver Oil, rising at the end of six weeks to ½ c.c per head per day. Pen No. 2 received an equal amount of Linseed Oil. Pen No. 3 received no oil but was simply fed on the basal ration alone. After 48 days' trial the following results were obtained:—

Pen No. 1 gave average increase per bird per day of 6.5 gramms.
Pen No. 2 gave average increase per bird per day of 6.9 gramms.
Pen No. 3 gave average increase per bird per day of 7.0 gramms.

At all the experimental centres the birds at the close of the experiment were all in good condition, and it is further added in the note attached to the West of Scotland Agricultural College Report that the birds in the "no oil" pen were more uniform in size and showed the best plumage.

These experiments show no evidence that any beneficial results follow the addition of Cod Liver Oil to rations such as are commonly used for chicks. The inclusion of fat soluble vitamins such as Cod Liver Oil does not appear to have improved the ration.

(*b*) Egg Laying Experiments. The conditions under which these were conducted were, on the whole, similar to the growth experiments.

Rowett Research Institute. Four pens were arranged. Pens No. 1 and 2 had 12 Leghorn Pullets each, and Pens No. 3 and 4 had 9 Leghorn Pullets each. Each pen was provided with a good grass run. The ration consisted of mash made up of bran, sharps, crushed oats, maize meal and fish meal and grain (equal parts of wheat, oats and kibbled maize). Pen No. 1 had 5 c.c Cod Liver Oil per bird per day, and Pen No. 3 an equal amount of Linseed Oil. Pens No. 2 and 4 had no oil to supplement their ration. Eggs laid during April, May and June were carefully recorded, with the following results:—

Pen No. 1 (C.L.O.) No. of eggs laid = 47.6 per bird.
Pen No. 2 (no oil) No. of eggs laid = 53.2 per bird.
Pen No. 3 (L.O.) No. of eggs laid = 53.0 per bird.
Pen No. 4 (no oil) No. of eggs laid = 52.1 per bird.

East of Scotland College of Agriculture. The conditions of the experiment as regards housing and basal ration were the same as in the growth experiment at the same Station. There were two pens with 10 Ancona pullets in each. Pen No. 1 had 1 c.c. Cod Liver Oil per bird per day, and Pen No. 2 1 c.c. Linseed Oil, in addition to the basal ration, and the experiment ran from September to June.

Pen No. 1 (C.L.O.) No. of eggs laid per bird = 86.0.
Pen No. 2 (L.O.) No. of eggs laid per bird = 85.6.

West of Scotland College of Agriculture. There were three pens here, each with 12 Leghorn Pullets and adequate grass runs were provided. Pen No. 1 received no oil; Pen No. 2, 5 c.c. Cod Liver Oil per bird per day, and Pen No. 3 an equal quantity of Linseed Oil. Results:—

Pen No. 1 (no oil) gave 143.6 eggs per bird in 8 months.
Pen No. 2 (C.L.O.) gave 123.5 eggs per bird in 8 months.
Pen No. 3 (L.O.) gave 121.8 eggs per bird in 8 months.

As the results of experiments at Rowett and West of Scotland College appear to indicate that the addition of Cod Liver Oil or Linseed Oil has an adverse effect on egg production, a further test was carried out at the West of Scotland College of Agriculture. There were in this experiment three pens with 20 Leghorn pullets in each. The birds were selected from those used in growth experiments the previous year and were kept in the " C.L.O," ".L.O." or " No oil " groups in which they had been during the growth experiment.

Pen No. 1 received no oil in their ration.
Pen No. 2 received 2.c.c. Cod Liver Oil per bird per day in their ration.
Pen. No. 3 received 2.c.c. Linseed Oil per bird per day.

The egg laying results were as follows:—

Pen No. 1 yielded 97.8 eggs per bird in 6 winter months.
Pen No. 2 yielded 93.4 eggs per bird in 6 winter months.
Pen No. 3 yielded 95.2 eggs per bird in 6 winter months.

Discussing the results, the evidence seems to warrant the following conclusions:—

(1) If "fat soluble vitamin" is required for egg production an ordinary ration contains sufficient.

(2) The addition of Cod Liver Oil to an ordinary ration is likely to decrease rather than increase egg production.

(*c*) HATCHABILITY EXPERIMENTS. To ascertain whether Cod Liver Oil has any effect on hatchability, some of the eggs from the Egg Production Experiments were hatched in incubators. The following table gives some of the results:—

	No. of eggs set.	*No. of eggs fertile.*	*Percentage of fertile eggs.* (*a*) *Hatched.*	*Percentage of fertile eggs.* (*b*) *Dead in shell or addled.*
C.L.O. Pen ...	49	35	34.3	65.7
L.O. Pen ...	25	18	33.3	66.7
No Oil Pen ...	50	28	92.9	7.1
C.L.O. Pen ...	50	37	75.7	24.3
L.O. Pen ...	50	37	86.5	13.5

Though the results lack the uniformity of the egg-laying test, they suggest that the hatchability of the eggs is not increased by the addition of vitamin-rich Cod Liver Oil to an ordinary ration.

The experiments recorded above do not touch the question as to whether or not fat soluble vitamin is essential for perfect nutrition in poultry, and no attempt is made to remove whatever vitamins may have been present in the basal rations used. The investigation was undertaken to ascertain whether or not the addition of a substance rich in fat soluble vitamin to ordinary rations has any beneficial effect. The results seem to provide a conclusive answer in the negative. Indeed, the results show that unless the oil is used in very small quantities it has a depressing effect on egg production.

SOME NOTES ON MOUNTAIN DISEASE.

(MOUNTAIN SICKNESS—*CLEFYD Y MYNYDD*).

By Norman Bissett, M.R.C.V.S.,
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This disease appears to affect horses between the ages of one year and five years only, and occurs in an area of about two miles radius, the central point being the farm of Cwmcyrnach on the Duffyrn Mountain, near Neath.

Three of the four positive cases one has seen have occurred in the practice of Mr. W. Jordan, M.R.C.V.S., Glais, to whom the writer is greatly indebted for his help and information.

The disease appears to affect the respiratory organs chiefly, and is referred to in Wallis Hoare's "System of Veterinary Medicine," where it is stated that the cause is unknown. This is the only reference one has been able to find.

Historical.

It appears that the disease is of a sporadic nature, but is not seasonal, as cases may be encountered at any time of the year. In some years, however, more animals are affected than in others, so much so that the term "outbreak" might be applied.

From conversations with old farmers, it appears that there have been several pronounced outbreaks of the trouble, the last being in 1891 and the one before that in 1874. Few details are available regarding the latter, but in 1891 50 per cent. of the horses in the district were tubed in order to render them serviceable for work. This was said to prolong the usefulness of some of them for a period up to 2 or 3 years, while others derived little or no benefit. All the affected horses had been pastured on the mountain, while the other 50 per cent., which were not affected, were stable fed. In this particular outbreak also, 13 horses died from the disease on one farm alone.

The farmers attribute the cause to the animals feeding on the mountain grass which they call "Fog," and which appears to be Matgrass (*Nardus stricta*).

The symptoms as described by the farmers appear to be identical with those observed during the present outbreak, which, as far as one can make out, is more severe than in any year since 1891,

although the losses are not so great as in that year. The writer has seen four positive cases of this disease.

Case 1.

3-year-old Welsh Mountain Pony, seen 31st March, 1924. Had been grazing on Duffryn Mountain during the summer and autumn of 1923. Developed Mountain Disease about November, when it was brought back to the stable, and had not been on the mountain, therefore, for 5 months. The writer enquired whether the fodder which it had been receiving since it was brought back to the stable had come from the mountain, and was informed that this was not the case.

To all outward appearances, the animal when at rest was perfectly normal, including temperature, pulse, and respiration. It was in good condition.

Symptons.

The animal was brought out of the stable and made to run up and down the yard for about one minute, when the symptoms commenced as follows:—The animal suddenly stumbled and began to show great distress in breathing, accompanied by a laryngeal noise resembling a combination of roaring and whistling. The muzzle was poked forward and the nostrils were widely distended. The distress gradually became worse, although the animal this time was stationary. In about five minutes he fell forward on his muzzle, and then on his right side, and remained down during the time the paroxysm lasted. which was in the first instance 2 hours.

A few days later, when the writer again saw the animal. the duration of the paroxysm was an hour and a half. A quantity of yellowish thick offensive smelling fluid was discharged from the nostrils, but there was no bleeding from the nose, though this has been said to occur in another case. During the paroxysm the animal perspired freely, and the peculiar laryngeal noise could be heard from a distance of fully 50 yards, while the heart could be heard beating from the other end of the stable.

The writer paid another visit to the farm on 7th April, having previously obtained permission to slaughter the animal, which was done by means of a humane killer just before recovery from the paroxysm. A post-mortem examination was made immediately.

Post-mortem.

The most outstanding feature was the enormous infestation by parasitic worms. including the tapeworms, Anoplocephala mammil-

lana, and the round worms, C.tetracanthum, S.edentatus, S.vulgaris, and S.equinus. Only one Oxyuris (whip-worm) was found. Numerous bots were adherent to the stomach lining. The tape worms were found in greatest numbers in the stomach and in the first part of the duodenum. None were found in the large intestine. On the whole, the writer has never before encountered such a massive and varied infestation. In spite of this, however, there was only slight gastritis and practically no enteritis. The stomach and intestines contained a normal quantity of food. There was no sign of the Matgrass, although the farmer mentioned that in other cases which he had seen opened, large quantities of the grass had been found. The lungs and respiratory tract generally appeared normal. The lining of the larynx was slightly injected. The aorta was rather distended, but the condition could hardly be described as Aneurysm. The distention was not due to parasitic influence. Unfortunately the method of slaughter had spoilt the chance of a satisfactory examination of the brain.

Case 2.

3-year-old mare, seen 25th July, 1924. This animal had been in possession of the farmer for about 11 weeks, being apparently sound when purchased. She had formerly been grazing on the Duffryn Mountain. She appeared to be perfectly normal when at rest, and was in good condition. If anything, she was slightly over nervous. The writer was informed that the symptoms of Mountain Disease had developed about a fortnight after purchase, and that they had been very pronounced on the Sunday previous to his visit, when the animal was reported to have shown, in addition to the symptoms described above. knuckling at the fetlocks, and signs of Radial Paralysis in the near fore leg. She had been lunged for about three minutes before the symptoms appeared, but after lunging was stopped, she recovered from the paroxysm in 10 minutes, and in a quarter of an hour was also walking sound.

On the 25th she was again lunged in the presence of the writer, and the peculiar laryngeal noise commenced in about 5 minutes, but there was no sign of knuckling or of lameness. The laryngeal noise was not so pronounced as in Case No. 1, and the animal was not nearly so distressed. There was no discharge from the nostrils, nor were the heart beats audible. In exactly 10 minutes from the time lunging was stopped, the mare was normal. The farmer stated that some of the attacks he had noticed had lasted for an hour and a half.

Case 3.

Yearling Welsh Mountain Pony, seen 25th July, 1924, belonging to owner of Case 2. Reported to have shown severe symptoms the previous Saturday. The animal was lunged for about 5 minutes, but showed no symptoms whatsoever.

Case 4.

3-year-old Welsh Mountain Pany. The history of this case is exactly the same as that of Case 3. It had shown symptoms the previous Saturday, but showed none in the writer's presence on the present occasion.

The writer visited the district again on the 1st August, but the animals again showed no symptoms on that day. Both the 25th July and 1st August, however, were days of incessant rain, whereas the 31st March and the 19th and 20th July, *i.e.*, the Saturday and Sunday previous to one's first visit, were hot, dry days. It may be, therefore, that the weather has some influence on the severity of the symptoms.

Case No. 3 was given to Mr. Jordan by the owner, and it was intended to have made a post-mortem on it on the first fine day, provided that definite symptoms could be observed. This fine day did not occur until the 8th August, and, on one's arrival, it was found that, most unfortunately, the animal had broken loose two days previously, had been so badly injured by wire that it had to be destroyed, and had been disposed of without a post-mortem being made.

One saw, however, Cases 2 and 4. Case 2 (the mare) was out at grass and on one's attempting to catch her she showed the distinct lameness above mentioned and also the laryngeal noise, which could be distinctly heard at least 80 yards away. She was caught and lunged after being given time to recover. On lunging the symptoms developed in half a minute, but she did not fall down, neither was there any discharge from the nostrils. The laryngeal noise also, although still a combination of roaring and whistling, had more of the roaring in it, whereas in Case 1 the whistling noise predominated.

The lameness was remarkably like Radial Paralysis. The animal showed the peculiar jerking forward of the shoulder on movement, but in addition the point of the elbow was thrown outwards at every step.

After the lunging was stopped, the mare recovered more rapidly than before and became apparently normal in five minutes, although the lameness did not quite disappear for about 10 minutes more.

This day was almost oppressively warm. In spite of this, however, Case 4, which one saw just afterwards, showed no symptoms whatever, though lunged until almost exhausted. This particular animal had been grazing on the Duffryn Mountain for a month before being brought to Glais on the 4th June. It showed distinct symptoms of the trouble at intervals up to 20th July. Since then, however, the writer was informed it had appeared perfectly normal and was certainly quite normal in every way on the 8th August.

All affected animals, those observed and those about which information has been received, are good stocky, colliery types, well ribbed home and in very good condition. When at rest they appear quite normal, with the exception, perhaps, of slightly nervous tendencies. They eat and drink well and are not in the least languid.

It would appear that the disease is of an intermittent nature, and it may be, as suggested above, that the weather has some influence on the incidence and severity of the attacks.

It will be noted, however, that there are several discrepancies and apparent inconsistencies in the various cases, and the whole question is, therefore, a very interesting one.

SOME RESULTS OF THE GLAMORGAN COUNTY LAYING TRIAL, 1923-24.

By F. H. W. Webb,

Ministry of Agriculture, Welsh Department.

There has been a good deal of discussion recently among persons interested in the welfare of the Poultry Industry in this country as to whether the amount of money and energy expended on the running of laying trials is justified by the results. There is much to be said in favour of the statement that most laying trials are simply competitions that have no value or interest except to poultry keepers who have entered their birds, or who happen to reside in the districts in which they are established. Fortunately, it does not apply to the Glamorgan County Laying Trial, which was run at Lower House Farm, Llantwit Major, from October 14th, 1923, to August 16th, 1924, under the auspices of the Glamorgan Agricultural Committee. The trial was made possible by the generosity of Ald. F. Harold Turnbull, and his Poultry Manager, Mr. C. Dunkley, who was in charge of the trial, deserves the highest praise for the excellent way in which it was managed. When the preliminary

preparations were being discussed, it was agreed that the trial should be something more than a competition. With this idea in view it was decided that the main objects should be:—

(*a*) To encourage and extend poultry keeping, and to improve the stock of poultry in the county;

(*b*) To demonstrate what are the egg-laying birds and strains suitable for poultry keepers in the county, anl to indicate where the desired stock can be obtained;

(*c*) To ascertain the most economical method and cost of feeding for egg production;

(*d*) To demonstrate the value of properly balanced rations which will produce a maximum output of eggs at a minimum cost.

In this article it is only proposed to deal with objects (*c*) and (*d*) as being of interest to poultry keepers generally, the competitive side of the trial being of little interest except to those resident in the county.

The trial commenced on Sunday, October 14th, 1923, with 66 pens of 4 pullets per pen. The birds were classified as Light and Heavy in accordance with the method adopted at Harper Adams Agricultural College, making 28 pens of the Light breeds and 38 pens of the Heavy breeds. Two birds from each pen were fed on wet mash and two on dry mash. The feeding was carried out under conditions that could easily be followed by the small poultry keeper. The mash, which was carefully balanced and gave a nutritive ratio of 1 to 5, consisted of:—

10 parts Bran; 5 parts Sussex Ground Oats; 20 parts Sharpes;
4 parts Fish Meal; 5 parts Maize Meal.

The birds on wet mash got as much as they could clear up and the birds on dry mash took it *ad lib.* The grain ration consisted of a mixture of equal parts of wheat, oats and kibbled maize, fed at the rate of 2 ozs. per bird per day. During the summer months the maize was stopped and equal parts of wheat and oats fed. Flint grit and Oyster Shell were provided *ad lib.*

Accurate records were kept throughout the period of the trial as follows:—

(1) The total cost of food per bird per week on Wet versus Dry Mash.

(2) The cost of food per egg produced on Wet versus Dry Mash.

(3) The cost of feeding all the birds for the period of the trial on Wet versus Dry Mash.

(4) Amount of Mash consumed per bird per day on Wet versus Dry Mash.

(5) Total number of eggs produced on Wet versus Dry Mash.

In each case the resulting figures have been in favour of the birds on the Dry Mash system of feeding.

(1) Cost of *food per bird* per week:—
Dry Mash 2.14d. Wet Mash 2.16d.

(2) Cost of food per egg:—
Dry Mash .91d. Wet Mash 1.13d.

(3) Cost of feeding for period of the trial:—
Dry Mash £46 6s. 4½d. Wet Mash £47 12s. 6½d.

(4) Amount of Mash consumed per bird per day:—
Dry Mash 2.06 ozs. Wet Mash 2.17 ozs.

(5) Eggs laid during the period of the trial:—

Dry Mash.		*Wet Mash.*	
First Grade.	*Second Grade.*	*First Grade.*	*Second Grade.*
8,330	9,704	7,945	7,894

The total value of eggs produced was £182 7s. 1½d.

In the above (1) (2) (3) and (4), the figures given are the averages for the whole trial. At the end of this article will be found a detailed summary giving the figures for each period of 28 days throughout the duration of the trials. Perusal of this will give some interesting figures as to the cost of feeding and production, the number of eggs and their quality, and the amount of mash consumed by the birds at different periods of the year. Although it is not the intention of the writer to deal with the competitive side of the trial, it may be of interest to give the results of the winning pens:—

Breed.	*Eggs laid.*		*Total.*	*Value.*
	First Grade.	*Second Grade.*		
				£ s. d.
Light Breeds— White Leghorn	541	115	656	4 17 8½
Heavy Breeds— Rhode Island Red	531	47	578	4 7 9

It is proposed to run a second trial on similar lines to the above, commencing on Sunday, October 12th, 1924, and ending on Saturday, 15th August, 1925. Accurate records will be kept and when the trial ends it will be possible to compare results obtained from an entirely fresh lot of birds, with those used in the trial under review. Until this can be done it would be unwise to draw any conclusive proofs from the results already obtained, even though they do point to the superiority of the Dry over the Wet Mash system of feeding.

The number of County Laying Trials are increasing in all parts of the country. The results obtained from the first trial ever held in Wales shows the amount of valuable information that can be got without in any way obscuring the competitive element.

DETAILED SUMMARY GIVING FIGURES FOR EACH PERIOD OF 28 DAYS THROUGHOUT THE DURATION OF THE TRIALS.

Each period of 28 days.	Number of Eggs Laid.				Cost of Food per Bird per Week.		Cost of Food per Egg.		Amount of Mash consumed per Bird per Day.		Total Cost of Food.	
	Dry Mash.		Wet Mash.		Dry Mash.	Wet Mash.	Dry Mash.	Wet Mash.	Dry Mash.	Wet Mash.	Dry Mash.	Wet Mash.
	1st Grade.	2nd Grade.	1st Grade.	2nd Grade.	d.	d.	d.	d.	ozs.	ozs.	£ s. d.	£ s. d.
October 14 to November 10	29	480	39	379	1.67	1.63	1.57	1.87	1.58	1.50	3 6 9	3 5 2
November 11 ,, December 8	106	994	75	630	1.65	1.51	1.34	2.51	1.75	1.45	3 6 0	3 0 0
December 9 ,, January 5	272	1,516	215	945	1.80	1.89	1.29	1.94	1.98	1.98	3 14 11	3 14 11
January 6 ,, February 2	676	1,972	588	1,370	1.96	2.11	1.09	1.17	2.27	1.99	3 17 11	4 3 1
February 3 ,, March 1	779	654	895	664	2.17	2.26	.72	.70	2.11	2.37	4 6 2¼	4 11 0
March 2 ,, March 29	1,135	846	1,302	742	2.45	2.57	.59	.59	2.3	2.54	4 17 0	5 1 0
March 30 ,, April 26	1,319	848	1,243	752	2.39	2.55	.53	.56	2.34	2.62	4 14 0	4 19 3½
April 27 ,, May 24	1,182	739	1,076	737	2.45	2.5	.59	.65	2.39	2.53	4 15 2	4.17 9
May 25 ,, June 21	1,051	649	889	640	2.36	2.51	.65	.76	2.15	2.43	4 11 11	4 17 1
June 22 ,, July 19	935	518	858	544	2.28	2.37	.73	.78	2.06	2.21	4 8 9	4.11 6
July 20 ,, August 16	846	488	765	491	2.27	2.25	.86	.88	2.04	2.25	4 7 9	4 11 9
TOTALS AND AVERAGES FOR WHOLE PERIOD	8,330	9,704	7,945	7,894	2.14	2.16	.91	1.13	2.06	2.17	46 6 4½	47 12 6½

THE NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING.

By R. Stenhouse Williams, M.B., D.Sc., D.P.H., etc.,
National Institute for Research in Dairying, Reading.

The National Institute for Research in Dairying is one of the research institutes which were founded by the Board of Agriculture as part of the scheme of agricultural research formulated under the Development and Road Improvement Fund Act, 1909.

As part of their policy for aiding and developing agriculture the Commissioners appointed to administer the Development Fund set out to secure, with the co-operation of the Board of Agriculture, the foundation of institutes for research on specified subjects of agricultural importance. Reading was chosen as the centre for dairy investigations, and in 1912 the Research Institute in Dairying was established at University College, Reading. The staff of the Institute, which consisted in the first instance of a bacteriologist, a chemist, and a laboratory assistant, was housed on the top floor of a dwellinghouse which had been adapted for laboratory purposes. It was not possible at the outset to provide the Institute with the experimental farm and dairy which were necessary for the full performance of its many functions. In its early days, the Institute was dependent for these facilities on the College Farm and the British Dairy Institute at the College. Assistance was always forthcoming from these sources when required, but it is evident that the help which can be given by departments whose primary duty is to teach, must finally prove inadequate for the purposes of a Research Institute.

Nevertheless, under these conditions, the work of the Institute developed and extended, and the staff increased, until the provision of greater facilities for the work became imperative.

In October, 1920, the Institute obtained possession of the Shinfield Manor Estate of about 350 acres, and the experimental farm was started with the farm buildings then existing. In June, 1921, by means of a grant from the Development Commissioners and private donations, it was possible to complete the purchase of the estate, and at this time the government of the Institute was reorganised. The Council of the College executed a Deed of Trust in relation to the property held for the Institute, under which the general control

of the Institute was delegated to a Governing Board, of which Viscount Elveden is the chairman, and on which are represented:—

The Ministry of Agriculture and Fisheries,
The Ministry of Health,
The Council of University College, Reading,
The Royal Agricultural Society of England,
The British Dairy Farmers, Association,
The National Farmers' Union,
The Subscribers to the Trust Funds of the Institute,
Persons engaged or interested in the industries or problems concerned with milk and milk products.

At this time the Institute adopted, with the consent of the Ministry of Agriculture, the title of the National Institute for Research in Dairying.

The work of adapting the Shinfield Manor House for laboratories and offices, of erecting the additional buildings which were necessary, and of installing plant for power, heating and lighting, was begun in January, 1922, and has recently been completed.

The accompanying picture gives some idea of the appearance of the new laboratories in which the work is now carried out and of the farm which is under the control of the Institute.

If any attempt be made to give a general indication of the functions of the Institute, it can perhaps be done in no better way than by quoting the following statement from a publication* on the progress of agricultural research in this country which has recently been issued by the Ministry of Agriculture:—

> The functions of a dairy research institute are wide. Within its province are included all questions relating to the production, handling and distribution of milk, and the manufacture of dairy products. These involve the study of the management and feeding of dairy herds, of methods of securing and distributing milk, of the constitution of milk and milk products, of the various activities in the dairy, of the technical processes involved in the making of such products as cheese and butter. The chemist, bacteriologist, physiologist, physicist, the specialist in dairy husbandry, and the animal pathologist are intimately concerned in one or other of the technical questions bearing on the subject. Further, the importance of milk from the human standpoint, and its relation to public health, give a value to dairy research quite apart from its agricultural value.

The carrying out of so wide a field of work requires that the staff of the institute shall have as complete a knowledge as possible of:—

(1) The chemical constitution and other properties of milk and milk products, including their food values.

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* *Agricultural Research and the Farmer.*

(2) The different conditions of management of cows and the effects of such management on the composition and properties of milk in dairy products.

(3) The chemical constitution, feeding value and other properties of foods given to cows and their effects upon milk and dairy products.

(4) The methods of handling and distributing milk and the effects of these upon the chemical constitution and other properties of milk.

(5) The methods of manufacture of dairy products and their effects upon butter, cheese, etc.

(6) Methods of cropping, stock management and breeding and their relation to successful dairy farming.

In addition to the problems which have been specifically mentioned, others must arise as time progresses and, indeed, it has already been found necessary to carry out a considerable series of experiments on tuberculosis in cattle in the interests of the dairy farmer, who is anxious to sell a milk which is not only clean but is also free from the germs of infectious disease.

That the scheme of work which has been outlined may be successfully carried out, the staff of the Institute comprises three main sections—Dairy Husbandry, Chemistry and Bacteriology. These three sections all work in close collaboration with each other and also do much work with others in institutions remote from their own. Such collaboration is essential if success is to be attained, for no one person can hope to have the knowledge necessary for the solution of many of the problems which are under investigation. It is also an indication that the members of the staff are live people with whom others are glad to work.

It is not possible to give a complete account of all the work that is going on within the Institute, but it may be of interest to describe one or two investigations which demonstrate how work may develop from one thing into another with far reaching results.

In 1919 a letter was received in the Institute from a breeder of pigs who was in the habit of storing whey and feeding it to the pigs after periods of storage. He wished to know what was the food value of the whey he was giving to the pigs. That enquiry was taken up by Capt. Golding, and has led to the conduct of long series of experiments upon two different lines; a series which is concerned with the vitamin values of food stuffs and a series which is concerned with the preparation of feeding stuffs from surplus

whey or with the preparation of the constituents of whey for trade purposes.

It is interesting to note that Capt. Golding had no sooner started with the former series of experiments than he found that others were interested in the problems with which he was concerned himself, and so we find the names of workers at University College, London; at the Lister Institute, at the British Dairy Institute, in addition to those of our own Institution upon the papers as they appear.

One series of experiments demonstrated that a diet of toppings and whey alone contained insufficient quantities of Vitamin A to produce satisfactory growth in pigs. It further demonstrated

(A) That a sufficient supply of this vitamin is necessary for the growth and development of sows to maturity and for the development of young pigs before birth.

(B) That Vitamin " A " in forms in which it is found in nature, *e.g.*, cream, green foods (lucerne) or cod-liver oil, stimulates the growth of pigs which have been declining in weight through the lack of this substance.

(C) That Vitamin " A " is stored up in the body fat when there is an ample supply of this substance in the diet.

(D) That no appreciable amount of Vitamin " A " can be detected in the body fat of pigs when they have been fed upon a diet which is deficient in this substance.

These two observations help to explain the variations in Vitamin " A " which are found to occur in lard.

(E) No definite rickets was induced by feeding on a diet deficient in Vitamin " A " even when suckling pigs were fed from the time they were four days old on a diet in which this factor was rigorously restricted, but growth was altogether arrested.

These experiments demonstrated the importance of supplying pigs with a food stuff which contains the necessary quantity of Vitamin " A " derived either from green foods or, when these are not available, from fish-meal, or cod-liver oil. They further led up to experiments upon the quantity of Vitamin " A " in milk and butter.

It was found that stall fed cows gave milk, the butter from which only contained 1/10th of the vitamin content of the butter made from milk of grass-fed cows. Small quantities of cod-liver oil added to the ration restored the full vitamin content of the butter, but not the colour of grass-fed butter. This work was then extended, with the result that the following observations were made:—

(1) Meadow hay was found to be superior to seeds hay as a source of growth promoting vitamin.

(2) The nature of any oil fed to the cow had a direct effect upon the composition of the butter fat. This was demonstrated by feeding arachis oil and coconut oil.

(3) Cod-liver oil was once more shown to have a marked effect upon the Vitamin "A" content of the butter and no unpleasant flavour was observed even when 8 ounces of this oil were fed daily.

(4) The slow response of pigmentation of the butter to grass feeding following the absence of colour under conditions of stall feeding was demonstrated.

Other interesting factors were observed in the study of milk of individual cows, such as differences in the time of churning and variations in the composition of the milk which will form the subjects of future work.

A consideration of the experiments which have been set out shows that many facts which are of great importance to agriculturalists have been demonstrated as the result of this work. Many other investigations must obviously develop from these facts. It is clear that the difference in growth promoting vitamin value of meadow hay in comparison with that of seeds hay must lead to more extended studies of the true food values of the food stuffs which are given to cattle and these again to a study of the reasons of these differences, which again must certainly lead to the study of the constitution of the land and its ultimate influence upon the stock.

The work which has been described represents one of the activities of the Institute. There are many others. Mackintosh, for example, has carried out investigations concerning the economic feeding of dairy cattle, the importance of milk recording, and the growth and uses of different types of crops. Much of his work is still under investigation, but much of it has already been found to be of great value to the dairy farmer.

The work which has been carried out at the Institute upon the methods of handling milk has been of material assistance in promoting a more satisfactory milk supply in this country. In addition it has been found that many of the faults which occur in the preparation of dairy products of different types are really due to errors in the methods of handling milk. This fact has led up to the study of the methods which are necessary for the preparation of dairy products from clean milk, a study which necessitates, in the case of cheese, a thorough knowledge of all the factors which go to the production of each kind of cheese. That this work may be done satisfactorily it will be necessary to investigate the chemical and

biological problems which are involved and the conditions of temperature and humidity which make for success in the ripening of cheese. It will also be necessary to know much more than we do at present of the nature of the milk from different breeds.

While all these investigations are being carried on, the staff of the Institute is constantly receiving appeals for help. Every effort is made to meet these appeals, which are of many different kinds, and although they add a certain difficulty in the carrying on of the work, it would be a great pity if they ceased to arise, since they show that the work of the Institute is appealing to those to whom it should appeal, namely, the dairy farmers and other members of the milk industry. They have the further advantage that they keep the members of the staff in touch with the outside world, and quite a number of the problems which have ultimately been found to be worthy of serious study have arisen in this way.

The chief danger which may arise as the result of work of this character lies in the fact that the workers in the Institute may tend to regard the immediate solution of a difficulty as the end of the problem. This is often true, but not by any means always. An illustration may make the meaning clear. In the early days of the Institute a Stilton cheese maker was suffering severely from discolouration in his cheese. It was found that this discolouration was due to micro-organisms which were contaminating the milk. It was further found that the action of the discolouring organisms could be controlled by increasing the amount of acidity in making the cheese. As an immediate measure of assistance, the cheese maker was advised to make use of a little starter in the making of his cheese. The results which he has obtained have shown that the advice was good, but the members of the staff of the Institute realised that it was their business to know exactly what were the causes of the discolouration, and whether it might not be possible to make satisfactory Stilton cheese from milk which did not contain discolouring organisms. The work has, therefore, been continued and a variety of papers have been published showing the varying factors which lead to the presence or absence of discolouration. In addition, experiments have been carried out in order to demonstrate the possibility or otherwise of making Stilton cheese from milk which did not contain discolouring organisms; that work is not yet complete, but it is hoped that now that the staff possesses a farm and a dairy it may be possible to bring it to a satisfactory conclusion.

SEED MIXTURES FOR TEMPORARY GRASS:

INVESTIGATIONS CONDUCTED IN DENMARK AND SWEDEN AND OBSERVATIONS ON TRIALS OF A SIMILAR NATURE IN PROGRESS AT ABERYSTWYTH.*

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I. Introduction.

Of the vast amount of work bearing on the management of grassland initiated in Denmark and Sweden during the latter part of last century, and subsequently greatly extended, none is of more profound significance to the British agriculturist than that relating to the problems connected with seed mixtures and putting land down to temporary grass. It is not to be supposed that the results of trials in Denmark and Sweden will as such necessarily apply to the conditions obtaining in England or Wales; it is, however, the broad implications of the Scandinavian investigations that should be kept in sight, and particularly by those who are planning grassland experiments in this country.

It is impossible in a short article to deal adequately with the numerous reports which have been issued, and endeavour will only be made to review briefly the comparatively recent works—chiefly the more important papers of Lindhard published subsequently to 1907, and some of the papers of Witte and other contemporary authors.

It will also be necessary to confine attention to lines of investigation which have not been followed up in an exhaustive or sufficiently critical manner in this country. It has been realised by the authors under review that an accurate knowledge of the characteristics, behaviour and potentialities of individual grass and clover species must form the starting point from which to build up reliable information as to seeds mixtures. The individual species has, therefore, been the unit of study; it has been investigated alone—as spaced plants and in pure plots—while in mixtures the behaviour of the component species has been ascertained by resort to botanical analyses.

* The Aberystwyth trials referred to in all cases have been conducted at the Welsh Plant Breeding Station, and in each case the Station reference number to the particular trial brought under review is indicated.

The most far reaching achievements of this mode of attack have been the direct outcome of the numerous nationality and strain trials which pointed the way to improvement of herbage plants by breeding—and which in turn lead to investigations of first rate importance relative to the best methods of seed production. It is with the papers bearing on the above subjects and with such matters as rates and dates of seeding, and with the behaviour generally of individual species alone and in seeds mixtures, that it is proposed to deal.†

II. Nationality and Strain Trials.

1. GRASSES. The earliest trials reported by Lindhard (13)* (1879—1907) deal only with different nationalities. A summary of the chief results with grasses is given in Table I, and is interesting as showing that in practically all cases, as good, and in many instances strikingly better yields were obtained with Danish grown seed than with that grown in other countries. More recent trials (1909—1917) conducted by Lindhard (17) (18) (22) indicate the marked superiority of strains developed by careful methods of selection adopted in Denmark for the conditions obtaining in that country in respect of a number of important herbage grasses.

† The papers relating to seed production will be dealt with in a subsequent article.

* Refers to the actual paper quoted as shown in the list of Literature Cited at the end of the article.

TABLE I. To Compare the Yield of Different Grasses from Seed grown in Denmark with that grown in other Countries.

Variety.	*No. of harvest years contributing to the average results.*	*Denmark.*	*U.S.A.*	*Sweden.*	*Germany.*	*Russia.*	*Finland.*	*Saxony.*	*Scotland.*	*Ireland.*	*France.*	*New Zealand.*
Cocksfoot ...	3	100	100	—	87	—	—	—	—	—	87	84
Perennial Rye Grass	2	100	—	—	—	—	—	—	90	87	—	—
Italian Rye Grass ...	1	100	—	—	—	—	—	—	98	100	94	—
Timothy ...	2	100	95	100	—	97	—	95	—	—	—	—
Meadow Foxtail ...	3	100	—	—	—	—	90	—	—	—	98	—
Tall Oat Grass ...	3	100	—	—	89	—	—	—	—	—	—	—
Meadow Fescue ...	3	100	84	—	86	—	—	—	—	—	—	—
Smooth Stalked Meadow Grass ...	3	95	100	—	—	—	—	—	—	—	—	—

Thus (1911—14) we find "Olsgaard" consistently out-yielding commercial American Cocksfoot, and in 1914—17 this strain taking the highest place in competition with a number of other pedigree strains. In the case of Perennial Rye Grass the pedigree strain "Landback" consistently and appreciably out-yields commercial Irish, while a pedigree strain of Italian Rye Grass from Tystofte shows to great advantage compared with ordinary commercial seed and with other strains.

Average results from eight trials (1914—17) show a pedigree Timothy (Trifolium Nr. 12) out-yielding ordinary Danish in the proportion of 122 to 100. Satisfactory results have also been obtained with Meadow Fescue, but with Tall Oat Grass the pedigree strains have apparently not shown substantial improvement on the ordinary French commercial seed (1909—12).

Results of a similar nature have been reported by Witte in Sweden (38) (39); thus at Svalöf, for instance, "Gloria" Timothy has out-yielded ordinary commercial Timothy as 118 to 100 and "Viktoria" Perennial Rye Grass has out-yielded ordinary commercial as 113 to 100.

An indication of the value of indigenous strains is afforded by the behaviour of "Jaedersk" Rye Grass* from Western Norway, which is an extra late and hardy form which has proved to be the best and most permanent strain for Norwegian conditions, and like indigenous strains of many of the grasses recently tested at Aberystwyth has shown to the best advantage in the second and subsequent harvest years, the yield being poor in the first harvest year.

Witte (38) states that this variety does best in damp and cold years, but is particularly susceptible to Crown Rust. Witte and Nystrom (46) have also reported that it shows to very considerable advantage on peaty and boggy soils, having out-yielded ordinary commercial strains by 73 to over 150 per cent. on the sum of five harvest years.

2. CLOVERS. With the clovers, as with the grasses, the earlier trials deal solely with nationalities and the later with pedigree strains, notable results having been achieved with pedigree selections of both Red and White Clover.

Important as nationality is in the case of nearly all species it is in respect of Red Clover that it is of such special significance, thus Lindhard (14) in his report on extensive trials (1898—1910) shows a range of productivity for over twenty nationalities from 112 (Danish Late Flowering) to 24 (Italian Broad Red). This range

* See Lindhard (11).

is compared in the statement hereunder with the range also given by Lindhard (15) for Alsike, White Clover and Trefoil when various nationalities have been under test in Denmark.

	Highest yield.	*Lowest yield.*
Red Clover	100 (Danish)	21 (Italian)
Alsike	100 (Swedish)	80 (Canadian)
White Clover	100 (Danish)	85 (German)
Trefoil	100	80

Trials conducted by Witte (36) (37) at Svalöf show a range of 100 (Swedish) to 31 for different nationalities of Red Clover, and only an average range of 100 (Swedish) to 63 for Alsike Clover, and are thus in confirmation of the Danish results.

It is of interest to note that neither English Late Flowering Red Clover nor English Broad Red Clover have taken a high place in the Danish or Swedish trials, while French, and particularly Italian, Broad Reds have done particularly badly. Of the late flowering Reds, seed grown in Denmark has done best, closely followed by Swedish and Norwegian. Danish, Silesian and Russian have been the best of the early strains, while from Bohemia productive strains of both late and early Red have been obtained.*

It is also worthy of note that Swedish Alsike has consistently and considerably out-yielded American and Canadian, based on the sum of two harvest years, both in the Danish and Swedish trials. The Swedish strains proved, however, to be somewhat later to mature than those from other sources. The Danish results serve to emphasise the very poor aftermathing ability of Alsike, which on the average only gave a hay to aftermath ratio of 100 to 18 and this for the Swedish strains which gave the heaviest aftermath, but at some centres even these gave an almost negligible aftermath.†

* Trials recently conducted at Aberystwyth by Williams (33) and (34) have been in precisely the same direction as those of Lindhard and Witte, and indicate the supreme value of home-grown strains for use in Britain.

† Trials conducted by Captain Williams at Aberystwyth (A.41) and not yet reported in detail have shown the following results:—

Nationality.	*Yield in lbs. per acre of green fodder.* *Seeding Year,* 1922.	*Yield in lbs. per acre of green fodder.* *1st harvest year,* 1923.	*No. of Plants per 5 square feet in spring of 2nd harvest year,* 1924.
English	8,790	22,480	11.3
Slovakia and Bohemia	10,250	20,900	5.1
Swedish	8,010	20,710	18.2
N. American	9,410	19,110	7.9

It will thus be noted, with the exception of the crop in the seeding year, that the North American seed has given results less satisfactory than English or Swedish—and that both Swedish and English have shown to particular advan-

3. COMPARISON BETWEEN BROAD RED AND LATE FLOWERING RED CLOVER. The outstanding difference between Late Flowering Red Clover and Early Flowering or Broad Red has been abundantly demonstrated by Witte (45) in his admirable summary of extensive trials conducted at Svalöf during the period 1908—21. A comparison made between Swedish Late and Silesian Early Red Clover gives the following average results:—

	1st cut.	*1st Harvest Year.* 2nd cut.	Total.
Silesian Red	100	100	100
Swedish Late	134	40	108
		2nd Harvest Year.	
Silesian Red	100	100	100
Swedish Late	399	64	223

It will be noted that even in the first harvest year Swedish Late, by virtue of its heavy first hay crop, and despite its poor aftermathing ability, gives the highest average aggregate yield, while in the second harvest year the first cut of the late Clover is practically four times greater than that of the early, and again, despite a smaller aftermath, the total yield is now more than twice that of the Silesian early.

In aggregate productivity over the two year period, the advantage is, therefore, strikingly in favour of the late strains, and this is the point of importance to farmers in districts where long duration leys are chiefly employed. Although the aftermath of the late clover is considerably less than that of the early, the difference is less accentuated if the late clover is cut relatively early, say at the first indication of flowering. The results under review show that on the average the late clover is less adversely affected by drought than the early—for on the score of its later growth in the spring and later date of cutting for hay, it can benefit by rain falling too late in the season to influence favourably the yield from the early Red. Lindhard (9) has shown furthermore that although Red Clover, like the grasses, is much influenced by rainfall, it is more sensitive to temperature than the grasses, and thus the late strains may escape injury from spring frosts or " freezing ". winds, which frequently coincide with a critical growth stage of the earlier starting strains, causing

tage in respect of the number of plants which have survived into the second harvest year. The Swedish Alsike was the latest to flower. It is to be noted also that whereas Red Clover nationalities have varied from 100 to about 30 at Aberystwyth, the above trial with Alsike only shows a nationality variation (based on first harvest year results) of 100 to 85—which is in keeping with the Danish and Swedish results.

very considerable damage.* It is the hardiness and persistence of the Late Red Clovers that should appeal to the Welsh farmer, particularly at high elevations, where, by virtue of the denser stands they give as the result of better over-wintering, they are likely to out-yield the early strains even in the matter of aftermath in the first harvest year.†

III. Behaviour of Danish and Swedish Strains in Wales.

It should not be supposed that the better of the pedigree Danish and Swedish strains of grasses and clovers will necessarily give good results in this country; the significance of the trials referred to is, however, the indication that they afford of the general superiority of home grown seed and that it is the business of every country to select for its own use strains well adapted to its particular needs. Witte (39) has shown further, that plant improvement is essentially a local undertaking, and that it is apparently necessary to breed and select for a characteristic district within the confines of that district. A good example is the case of a pedigree Timothy bred at Lulea (in Sweden) which at Lulea out-yielded ordinary Swedish Timothy as 119 to 100, but at Svalöf stood in the relation of 85 to 100.

Some indication of the behaviour of Danish and Swedish pedigree strains in this country is given by trials at Aberystwyth (e.g. B.101), which suggest that certain of these should be subjected to more comprehensive tests. Strains of Swedish Late Flowering Red Clover have given excellent results, and the same has been true of Danish "Olsgaard" and "Desgaards" Cocksfoot, but these latter are essentially hay forms and in this country are not more persistent than ordinary Danish commercial. Swedish "Scandia" Cocksfoot, which is a more leafy and more persistent form, has also given good results, as has a pedigree Italian Rye Grass. The Danish pedigree Perennial Rye Grasses did not give better results than some of the home grown commercials, while Svalöf "Victoria," although yielding decidedly well, could not be said to be strikingly superior to the best commercial lots. In the case of Meadow Fescue, Svalöf "Original" did not do as well as ordinary commercial in the first harvest year, but in the second harvest year was superior in the proportion of

* See Witte (41), Lindhard (9), and Rhodin (28), for a more detailed discussion of the influence of climatic conditions on the yield of grasses and clovers. Witte's paper has been briefly summarized by Stapledon (30), who has also given the results of trials conducted in Wales, while Williams (33), discussing his trials with Red Clover at Aberystwyth, has also noted the ill effects of early spring frosts on the early Red Clovers, conditions which were without appreciable harm to the late strains.

† An exposed field sown in Cardiganshire at 700′ above sea level in 1920, partly with Montgomery extra Late Red Clover and partly with ordinary Broad Red, was strikingly in favour of the Montgomery Clover, even in the aftermath (1924)—the amount of grazing being obviously greater where this clover had been sown.

109 to 100. In a trial with eleven lots of Timothy Svalöf "Gloria" gave the highest yield in both the first and second harvest years and appears to be a particularly promising strain.

Of the Danish pedigree strains the following are now particularly recommended by the Danish Authorities (1):—Perennial Rye Grass "Lundback"; Italian Rye Grass "Tystofte No. 152"; Meadow Fescue "Strain No. 9 Faellesforeningen"; Cocksfoot "Olsgaard"; Late Red Clover "Hersnap" and White Clover "Morso." Samples of the above and also pedigree strains of cereals, roots and other agricultural crops can be obtained at a small cost from the Royal Danish Agricultural Society, Vestre Boulevard 34, Kobenhavn, B.

The chief Svalöf strains are now as follows:—"Gloria" Timothy, "Scandia" Cocksfoot, "Victoria" Perennial Rye Grass, and "Original" Meadow Fescue, also "Swedish" Late Flowering Red Clover. Supplies of these can be procured through the Svalöf Agents in the United Kingdom, Messrs. W. A. Temperley and Co., 2 St. Nicholas Buildings, Newcastle-upon-Tyne.

IV. The Yielding and other Properties of Different Species of Grasses Compared.

1. Relative Yielding Ability. Lindhard (11) gives details of important trials (1880-1904) conducted on sand, clay and in a wet-lying situation with the chief grass species; some of the more important results are set out in summary form in Table II.

It will be seen that Tall Oat Grass has excelled in yield in both the first and second harvest years, except on the boggy situation. Cocksfoot has fallen far short of Tall Oat on sand, but on clay in the second harvest year has been the most productive grass, while on the wetter situations it has taken a high place in both the first and second years. Timothy showed to excellent advantage on the bog area, conditions which were also very favourable to Meadow Foxtail. The falling off in productivity of Perennial Rye Grass on each soil class in the second harvest year is strikingly shown, as is the yielding ability of *Agrostis* in the second harvest year on clay.

TABLE II. To show the comparative yields of some of the more important species of grasses in the first and second harvest years, when grown as pure species respectively on Sand, Clay and Bog.

	Sand.		Clay.		Bog.	
	1st yr.	2nd yr.	1st yr.	2nd yr.	1st yr.	2nd yr.
Tall Oat	100	100	100	100	100	100
Cocksfoot	51	80	62	102	115	123
Timothy	64	42	67	91	141	111
Perennial Rye Grass	84	53	85	64	155	95
Meadow Fescue	56	51	65	77	174	124
Foxtail	35	33	44	54	104	104
Agrostis alba	44	52	74	100	104	91

The Swedish trials reported by Witte (38) and (41) also show Perennial Rye Grass less productive than Timothy, Cocksfoot, Meadow Fescue or Tall Oat Grass over a period of two harvest years. Tall Oat Grass has substantially out-yielded the other grasses in the second harvest year, and taking the two years together, has proved itself the heaviest yielding species. At Svalöf Meadow Fescue has taken a relatively higher place than in Denmark, and in the first harvest year has out-yielded Rye Grass, Cocksfoot and Timothy; in the second harvest year its yield has been very similar to that of Timothy and Cocksfoot. On the average of the Swedish trials Cocksfoot appears to have slightly out-yielded Timothy. Taking the Danish and Swedish trials together and considering the sum of the first and second harvest years, and the sum of two cuts in each year, it would seem evident that Tall Oat Grass, Cocksfoot, Timothy and Meadow Fescue are the four heaviest yielding grasses.

2. Manner of Growth. The manner of growth of the grasses has been closely studied by Lindhard (10), (11), (16) and (23), Osvald (25) and others. The agricultural value and special uses of the various species has been shown to be intimately connected with differences in manner of shoot development.* Permanent species are generally able to flower and increase vegetatively at the same time, but many of these resemble biennials in their habit of growth. Under certain conditions this is particularly true of Perennial Rye Grass, Rough Stalked Meadow Grass and Yorkshire Fog. Although most of the grasses, if grown as spaced plants on fertile soil, develop panicle bearing shoots in the autumn of the seeding year, and under such conditions will certainly flower in the first harvest year, and while many species also tend to behave in a more or less similar manner when sown in simple seeds mixtures—in most cases their behaviour will be very different when fully established on adult and dense swards. Under sward conditions some grasses produce only one generation of shoots in each growing season, while others produce two generations. In some grasses the production of panicle bearing shoots is a process taking two or three years for any particular set of shoots; in others the whole cycle may be completed in one or two years.

Certain species, therefore, consist largely of root leaves and leaf shoots throughout practically the whole year, stem shoots and panicle

* "Shoots" are conveniently defined as: (1) panicle shoots, being such as bear panicles during a particular season; (2) stem shoots, being such as have definitely elongated internodes—these are "fertile" if they will bear panicles later in the season and "barren" if not; (3) leaf shoots are barren and consist only of blades and sheaths of the leaves, the internodes not having elongated. See also Stapledon (30).

bearing shoots only being abundant during the hay period, such are many strains of Meadow Foxtail and Cocksfoot; others consist predominantly of leaf shoots at one period and of stem shoots at another, such are grasses with a biennial habit like Perennial Rye Grass. Species like Tall Oat Grass have a very short period in the leaf shoot stage—the shoots extending early into stem shoots with elongated internodes, most of them terminating in panicles at the hay stage. The effect of grazing on grasses with a tendency to develop elongate stem shoots and the minimum of long duration leaf shoots reacts against persistency and thus ordinary commercial strains of Tall Oat Grass, Timothy and Golden Oat Grass do not long withstand heavy grazing—the effect of reasonable grazing on grasses like Perennial Rye Grass and Rough Stalked Meadow Grass is, however, rather to encourage the development of leaf shoots and thus on well manured and judiciously grazed pastures these grasses become truly perennial, a fact which is also true of Yorkshire Fog on the richest grazing lands.

It will be apparent that shoot development, both quantitatively and qualitatively, is very dependent on time of sowing, methods of management and general conditions of fertility, and for most species varies considerably with different strains. This is well seen in the case of Perennial Rye Grass and Rough Stalked Meadow Grass—in a sown ley these grasses will at first tend to behave like true biennials, forming abundance of leaf shoots in the autumn and flowering freely in the first harvest year; as the sward becomes denser, as it rapidly will under the influence of Wild White Clover, a more tufted growth (with more continuous development of leaf shoots) is favoured and the grasses assume a more definitely perennial habit; a habit which Perennial Rye Grass from sowing will never assume on poor soils, and thus its contribution is often slight in leys after the second harvest year, while on such situations Yorkshire Fog functions more as a biennial than as a perennial and perpetuates itself chiefly by abundant re-seeding favoured by delayed harvests.

Brief notes are given relative to a few of the more important grasses in relation to their behaviour under sward conditions.

ITALIAN RYE GRASS. This grass is a typical biennial and develops numerous leaf shoots during the first autumn and even during the winter, growth being continuous as long as the conditions are favourable. In the following spring the leaf shoots develop into moderately leafy panicle bearing shoots at the hay stage. In the aftermath, which is usually abundant, panicle shoots again predominate. It is

the ability to develop abundance of root leaves and leaf shoots during the autumn and during the winter which renders Italian Rye Grass of such outstanding value for providing winter and early spring grazing.

PERENNIAL RYE GRASS. Perennial Rye Grass forms vigorous leaf shoots in the autumn and thus also affords appreciable if not abundant winter keep, and under relatively severe conditions has a much greater ability for over-wintering than Italian Rye Grass. In the spring this grass develops numerous and particularly leafless flowering stems, the hay consisting almost solely of such flowering stems; the aftermath grows slowly and with difficulty and only in wet seasons affords good summer grazing; growth, however, becoming more vigorous early in the autumn, when leaf shoots are again freely developed.

ROUGH STALKED MEADOW GRASS. This species when established on swards has usually a three year shoot development. In the autumn large numbers of delicate leafy shoots are formed, consequently quite appreciable winter and early spring keep is provided. The close growing leaf shoots do not contribute appreciably to the hay, but large numbers of fairly leafy panicle shoots are always developed. The aftermath yield and the summer grazing are usually but slight.

COCKSFOOT. More than one generation of shoots is usually formed in each growing season. This species has a two to three year shoot development. The leaf shoots do not develop into stem and panicle shoots till after the lapse of one or two years, thus early in the summer barren shoots predominate. The hay consists in part of tall, vigorous flowering stems, and in part of leaf shoots. If heavily manured in the autumn the hay crop the following year will consist almost wholly of stem shoots. The aftermath consists predominantly of root leaves and leaf shoots. Cocksfoot, however, yields a heavy aftermath and affords good summer grazing.

MEADOW FESCUE behaves in a manner very similar to Cocksfoot, but usually only one generation of shoots is formed annually. Like Cocksfoot it gives a rather leafy hay consisting of both panicle and leaf shoots, but except on damp situations the aftermath is usually meagre. Meadow Fescue has a higher intrinsic capacity for over-wintering under severe conditions than either of the Rye Grasses, but like other grasses is hampered in this respect by over-crowding.

TIMOTHY. This grass has almost exclusively erect shoots with extended internodes; usually more than one generation is formed per

growing season and shoot development is annual. The hay consists almost entirely of rather leafy panicle bearing shoots, or partially of panicle shoots and partially of stem shoots; leaf shoots and root leaves being of negligible significance. The aftermath development is always relatively slight, but in wet seasons a small second crop of panicle shoots may be produced. Late in the autumn a meagre grazing consisting only of root leaves is developed.

TALL OAT GRASS. Like Timothy has erect shoots with extended internodes. The new shoots arise in the autumn but make no winter growth and are covered and protected by the withered leaves—thus this grass affords no late autumn and winter keep. Early in the spring the shoots elongate and the hay consists almost exclusively of panicle bearing shoots or stem shoots. The after cut is invariably good and again consists exclusively of panicle and stem shoots.

GOLDEN OAT GRASS. In shoot development this grass is similar to Tall Oat Grass, but gives a very much poorer aftermath.

MEADOW FOXTAIL. Barren leaf shoots are produced in very large numbers; the development of panicle shoots usually takes from two to three or even more years, and is only abundant under favourable conditions. The stems are tall, and as such poor in leaves, and usually develop intermittently over a rather long period (April to June). Owing to excess of leaf shoots the hay is always leafy, while the aftermath consists almost exclusively of leaf shoots.

V. Date and Methods of Sowing.

Lindhard (9) in particular has shown as the result of botanical analyses made on seed mixture trials, initiated by Nielsson at 13 centres extending over a ten year period, that final establishment, even into the first harvest year, is overwhelmingly influenced by a number of variable factors which react differentially on the several species as such, and which are influenced most diversely by the conditions at each centre, and by the climatic conditions obtaining in each year. It is thus apparent that the drawing up of a mixture merely on a mathematical basis, having regard to the laboratory germination of the seed and the amount of ground it is intended to cover with each species, is to ignore some of the most fundamental influences affecting the success of the undertaking. The papers here under review, while chiefly indicating the extreme complexity of the problems involved, are, however, decidedly informing on certain fundamental points which have been very generally overlooked in this country, namely: the intrinsic capacity of the different species

for soil germination (as opposed to laboratory germination) and for early establishment, their capacity for over-wintering into the first harvest year, and the influence of date of sowing on establishment and yield.

1. ESTABLISHMENT. It is evident in the first place that seedling establishment in the seeding year and the capacity to over-winter into the first harvest year are two quite distinct phases of final establishment, and that species with a high average ability for seedling establishment have not necessarily good over-wintering properties. Seedling establishment is estimated by ascertaining the percentage of the viable seed sown which gives rise to established plantlets, and is invariably considerably less than 100 per cent, is very seldom as high as 60 per cent, and taking all the species of a mixture it would appear that usually only about ¼ to ⅓ of the viable seed sown gives rise to established plants.

The average ability of the different species in this connection is indicated in the following statement, which is taken from Lindhard (9) and (21), and is based on data collected from relatively simple mixtures sown on over 50 (and frequently over 100) different fields for each species:—

Percentage of viable seed producing established plants.

	Jutland. 1905—1910.	*Lolland-Falster.* 1877—1886.
Red Clover ...	60.9	49.5
Alsike Clover ...	46.6	23.4
White Clover ...	44.0	26.7
Italian Rye Grass ...	39.5	39.2
Perennial Rye Grass ...	79.6	60.3
Tall Oat Grass ...	59.8	44.1
Cocksfoot ...	53.0	21.4
Meadow Fescue ...	46.6	23.7
Timothy ...	27.2	10.2

The above comparison is interesting as showing that considerably better establishment was achieved on the light Jutland soils than on the heavy Falster soils, but in the main the species take the same order in both sets of trials. It is to be noted that Alsike Clover and White Clover have decidedly less ability for establishment than Red Clover. The Falster series show that Red Clover only once fell below 30 per cent in the nine years, while both Alsike and White Clover in three years fell below 20 per cent. Of the grasses, Perennial Rye Grass not only takes the highest average place but has not once fallen below a 50 per cent establishment. Tall Oat Grass has not fallen below 30 per cent and has shown itself con-

siderably more reliable in establishment than Italian Rye Grass, Cocksfoot or Meadow Fescue; the two latter grasses have fallen as low as 20 per cent, while Timothy, with a very poor average establishment has fallen as low as 5 per cent.*

2. OVERWINTERING. With reference to over-wintering, Lindhard states that there is more than an indication that plants tend to over-winter into the first harvest year in inverse proportion to the density of their stand (excellence of establishment) in the seeding year.† Thus Timothy over-wintered 16 per cent. better from its lowest establishment than from its highest, and Meadow Fescue with rather poor average establishment always appears to over-winter well. The grasses tend to over-winter decidedly more satisfactorily than the clovers—in this respect Red Clover, Alsike Clover and White Clover are very similar, although White Clover is decidedly fickle. There appears to be evidence for thinking that White Clover, Meadow Fescue and probably some other species also give somewhat exaggerated over-wintering figures by virtue of delayed germination, some proportion of the seed failing to germinate until the spring of the first harvest year. Italian Rye Grass in Denmark has proved one of the least satisfactory grasses to over-winter; Meadow Fescue and Timothy over-winter decidedly well and are probably slightly superior to Cocksfoot and Tall Oat Grass.

In Jutland Perennial Rye Grass over-wintered better than Cocksfoot and Tall Oat Grass, while at Falster the position was reversed.

3. SEED RATE. It will be apparent from the foregoing considerations that it must be almost impossible to lay down general rules as to optimum seed rate for the different species when sown pure, and even more difficult to do so in the case of mixtures.

(*a*) PURE SPECIES. It is important to ascertain the correct seed rates for pure species with a view to the proper conduct of nationality trials, and although the rates indicated for a species when grown

* Trials reported upon by Williams (32) and further trials now in progress at Aberystwyth lend emphasis to the relatively poor percentage establishment given by grass and clover seeds under field conditions and in the main would seem to put the species in much the same order as the Danish experiments. Italian Rye Grass at Aberystwyth has, however, shown to nearly as good advantage as Perennial, while Meadow Fescue has proved itself even more fickle and unreliable than indicated by the place taken in the Danish trials. Both Alsike and White Clover have been far less satisfactory than Red. Timothy, as in Denmark, has given decidedly low results.

† "Initial establishment" is ascertained by making counts in the autumn of the seeding year and "over-wintering" by making counts in the spring of the first harvest year: the number of plants which became fully established into the first harvest year, of course, depending upon both the capacity for "initial establishment" and "over-wintering."

pure can not afford a definite criterion for the rate of the same species in a mixture, it is yet pretty certain that a grass or clover demanding a high rate when pure will be likely to have a poor chance in a mixture if included only in small amount.

Trials conducted by Lindhard (8) and others, although showing considerable differences in the rates giving the highest yields at different centres and under different conditions, definitely prove that the excessive rates originally advocated by Stebler (31), such as 53 lbs. Perennial Rye Grass and 26 lbs. of Timothy, are now invariably unnecessary. The rates, of course, depend on the viability and size of the seed, but with modern seed of ordinary good quality maximum yields have been obtained by Lindhard with the rates given below, while Witte advocates rates as stated, and for comparison the range of rates which have proved the most successful at Aberystwyth are also shown (in lbs. per acre respectively).

	Lindhard in Denmark.	*Witte in Sweden.*	*At Aberystwyth.*
Tall Oat Grass ...	35 lbs.	—	35 lbs.
Perennial Rye Grass ...	12 lbs.	26 lbs.	15—20 lbs.
Cocksfoot ...	10 lbs.	—	18—20 lbs.
Timothy ...	9½ lbs.	—	12—15 lbs.
Meadow Fescue ...	10 lbs.	19½ lbs.	20—25 lbs.
Rough Stalked Meadow Grass ...	—	—	14 lbs.
Smooth Stalked Meadow Grass ...	—	13 lbs.	—
Red Clover ...	16 lbs.	8—14 lbs.	15 lbs.
Alsike Clover ...	—	8—10 lbs.	8—10 lbs.

An examination of the above figures strongly suggests that the disparity between the amounts of Perennial Rye Grass on the one hand, and of Cocksfoot and Timothy on the other, usually included in mixtures in this country is quite uncalled for—the above rates being based on actual yields of course allow for "establishment" and "over-wintering" (in which Perennial Rye Grass excels) as well as for the size and viability of the seed.

It is evident from Lindhard's results that sometimes half of what may normally be regarded as an adequate seeding will give a full crop and that comparatively heavy seed rates are presumably advisable, because on the average they probably give the most certain results. Taking the evidence as a whole, there is an indication that higher seed rates are necessary in districts of considerable average

* It must be remembered that when Stebler conducted his trials and collected his information the average viability and quality of grass and clover seeds were not nearly as high as they are to-day.

rainfall than in somewhat drier localities, and that this is in part due to the difficulty of obtaining a good tilth under the former circumstances and in part to conditions unfavourable for over-wintering. It would also appear that granted an adequate stand: (1) the heaviest yields will result from relatively thin rather than from excessively dense stands under conditions of high soil fertility and therefore from the lighter seedings if conditions for establishment have been favourable. (2) On soils incapable of high crop production the heaviest yields will result from the heaviest initial stands and therefore from the more generous seed rates.

(*b*) MIXTURES. Trials conducted by Rhodin (27) in Sweden and at Aberystwyth show that under some circumstances an addition to the seed rate of a mixture as a whole adds appreciably to the yield, while in other cases just as with pure species very considerable reductions hardly influence the yield.

Rhodin (27) gives the results from a simple mixture consisting of 70 per cent. Timothy, 20 per cent. Alsike and 10 per cent. Red Clover sown at the following three rates in lbs. per acre:—

	Thin seeding.	*Normal seeding.*	*Thick seeding.*
Timothy ...	14.9	18.7	22.4
Alsike ...	4.2	5.3	6.4
Red Clover ...	2.1	2.6	3.2
Total ...	21.2	26.6	32.0

The trial was conducted on nine different farms, for the most part on stiff clay soil in fertile condition and of high productivity. The results from various centres comprised fifteen crops in the first harvest year, eleven in the second and twelve in the third. At practically all centres and in each harvest year, the heaviest seed rate gave the highest yield. The relation of the yields from all the trials for the three harvest years together was as follows:—

Thin seeding.	*Normal seeding.*	*Thick seeding.*
100	107	114

The results obtained at Aberystwyth (E.8) were in the opposite direction to those of Rhodin, as will be seen from the particulars hereunder. The mixtures used were as follow:—

	Full seeding.	*¾ seeding.*	*½ seeding.*	*¼ seeding.*
Italian Rye Grass ...	10 lbs.	7.50 lbs.	5.00 lbs.	2.50 lbs.
Cocksfoot ...	5 lbs.	3.75 lbs.	2.50 lbs.	1.25 lbs.
Broad Red Clover	5 lbs.	3.75 lbs.	2.50 lbs.	1.25 lbs.
	20.00 lbs.	15.00 lbs.	10.00 lbs.	5.0 lbs.

The mixtures were sown on replicated rod plots, one series under rape and the other without a nurse crop in June, 1920. The yields in the first harvest year (1921) showed no material differences between the two methods and the relation of the different seed rates based on the average of the plots (four in all for each seed rate) with and without rape may be expressed as follows:—

¼ *seeding.*	½ *seeding.*	¾ *seeding.*	*Full seeding.*
100	101	107	103

Thus a seeding of 15 lbs. per acre actually gave a heavier yield than 20 lbs. per acre, while only 5 lbs. per acre yielded as heavily as 10 lbs. per acre, and but little less than 15 lbs. or 20 lbs. per acre. It should be pointed out that the trial was conducted on fertile land and that the conditions for germination and establishment were particularly satisfactory.

It will be obvious, of course, that yield is a function of the number of plants per unit of area and the size of the individual plants—the heavier seed rates presumably giving rise to a large number of relatively low yielding plants and the low rates to a smaller number of relatively high yielding plants. Thus, if a low rate is sufficient to ensure a stand, and a very low rate may well be adequate under ideal conditions, the differences in yield between the different extreme rates are likely to be relatively insignificant, and such was the case in the particular trial under review.* It does not follow, moreover, that establishment in terms of plants per unit of area will be proportionate to the seed rates, indeed the following comparison based on counts in the autumn of the first harvest year show that a larger proportion of the seeds sown at the lower rates actually produced fully established plants than of the seeds sown at the higher rates:—

	Expected establishment.	*Actual establishment.*†
Full seeding ...	100	100
¾ seeding ...	75	85
½ seeding ...	50	71
¼ seeding ...	25	40

† The actual number of plants of the sown species on the full seeding plots expressed as 100 and the number of plants on the other plots proportionately. Based on 40 readings per rod plot with a mesh 6″ × 6″ (average of 4 plots in each case). For full and detailed particulars see Davies (4).

* The produce from the lower rates will, of course, have consisted of a greater proportion of unsown species than will have been the case from the higher rates and this will tend to level up the yields. The following percentage figures, based on counts made on the plots after harvesting the first year's hay crop show this:—

	Full seeding.	¾ *seeding.*	½ *seeding.*	¼ *seeding.*
Unsown species per cent.	30.9	33.2	41.5	55.9

It will be noted, however, that the difference in the contribution between the full and ¾ seed rates has not been material. The proportions taken by the various sown species under the different rates is dealt with subsequently (see p. 91).

Thus the half seeding proportionate to the full seeding produced practically as good a stand as would have been expected from a ¾ seeding, and the ¼ seeding nearly as good a stand as might have been expected from a half seeding.

4. Date of Sowing. The influence of date of sowing on establishment has been demonstrated by trials conducted by P. Nielson (1877—1886) and reported by Lindhard (7), in 1906. The aim of the trials was to investigate the best means of re-seeding, in the autumn, fields that had more or less failed to "take" from ordinary spring sowing. It was found that after adequate harrowing after the removal of the covering crop, seeds sown in the autumn germinated satisfactorily, but that the delicate seedlings over-wintered very badly and this was particularly true of the clovers, which almost completely disappeared by the following spring. Of the grasses, Tall Oat Grass, Perennial and Italian Rye Grass established themselves most satisfactorily from autumn sowing, but the earlier the sowing the better the establishment, and even when fair establishment had been achieved, the cropping power in the first harvest year of the plants so developed was considerably less than that of plants which had established themselves from the normal spring sowing.

Witte (42) more recently (trials 1911—1921) has investigated the matter by sowing the same mixture in the middle of May, June, July and August respectively on a peaty soil. The mixture used was at the rate of 36½ lbs. to the acre, and consisted of Alsike Clover, 20 per cent.; White Clover, 10 per cent.; Timothy, 35 per cent.; Meadow Foxtail, 10 per cent.; Meadow Fescue, 20 per cent.; and Smooth Stalked Meadow Grass, 5 per cent.

In the first harvest year the yields from the different sowings were as follows:—May, 100; June, 99; July, 82; and August, 49.

Thus the August sown plots yielded only half as well as those seeded in May and June. The Clovers were most highly represented after the June sowing and most poorly after the August. Timothy and Meadow Fescue were in greatest evidence on the May sown plots, while Rough Stalked Meadow Grass (unsown) was most plentiful on the August plots. The yield in the second to fifth harvest years showed no relation to the date of sowing, the composition of the herbage, however, revealed certain differences even in the later harvest years.

Trials now in progress at Aberystwyth (E.33) are in marked confirmation of the above results and seem to indicate that under the conditions obtaining in Central Wales sowing in August is not to be recommended, and that even July is frequently likely to be

too late—as in Denmark, Perennial Rye Grass, Tall Oat Grass and Italian Rye Grass have established themselves considerably better than other grasses from August sowings, while the clovers have been the least satisfactory. The reduction in hay yield in the first harvest year from sowings made in August compared with those made earlier, although not as great as those recorded by Witte, has been very appreciable, while from sowings made in September equivalent results have been obtained to those recorded by Witte for August.*

VI. The Influence of a Nurse Crop.

Rhodin (28), as a result of an extensive series of trials conducted on clay soil in dry situations, found that seeds mixture plots sown without a nurse crop and under corn cut early as green fodder gave about equal crops in the first harvest year—while similar mixtures sown under corn allowed to ripen fully gave heavier crops—for his grass mixtures the ratio being: without a nurse or with corn for fodder *to* with corn allowed to ripen 100 to 116. Under the conditions of the trial Rhodin concludes that the advantage in favour of the ripening corn was due to the fact that throughout the spring and summer the young seeds were protected from drying out.

The effect of a corn crop on the establishment of a seeds mixture was tested at Aberystwyth in 1920, a year in which there was no possibility of the young seeds suffering from drought at any period. The full, ¾, ½, and ¼ seeds mixtures previously referred to (E.8, see p. 75) were sown under a full (= at rate of 3,000,000 viable seed per acre), half and quarter seeding of Sixty Day Oats. In considering the effects of the corn crop the average results of the full and ¾ seeds mixtures (which represent more or less normal seed rates) need only be brought under review. The essential details are set out in Table III.

Only the full seeding of oats can be regarded as typical of a normal crop allowed to ripen, while the quarter seeding did not produce anything approaching either a crop of grain or straw.

It will be noted that the highest yield of grain, straw, grasses and clovers together was obtained off the plots on which the oats were only given a quarter seeding, but that practically 70 per cent. of this bulk consisted of grasses and clovers. Under the wet conditions of 1920 the grasses and clovers grew luxuriantly from the start and were hardly hampered by this light corn crop. This vigorous

* The Aberystwyth trial has been set up with pure species sown at intervals of 14 days from April 1st to the end of October, and is at present only in its first year and will be reported upon in detail in due course.

growth of grasses and clovers, however, set up a keener intra and inter specific competition amongst themselves than did a thicker corn crop, which retarded the growth of the individual grass and clover plants very considerably, and thus under the quarter nurse crop the actual stand of the grasses and clovers—judged by the number

TABLE III. To show (1) the yield of grain and number of days to reach maturity of the corncrop (Nurse) at three rates of sowing; (2) the total yield of grain, straw, grasses and clovers together; and (3) the number of established plants, grasses and clovers together, under the influence of the three rates of sowing of the Nurse Crop. Data obtained in the seeding year. Yields in lbs. per acre. The figures in brackets give relative results.

Rate of seeding of Nurse crop.	*No. of days for corn to reach maturity.*	*Yield of grain in lbs. per acre.**	*Yield of grain, straw, grasses and clover together in lbs. per acre.*	*No. of established plants of grasses and clovers together per acre.*
Full seeding	123	1057	4788 † (100)	2,107,000 (100)
½ seeding	131	839	3520 (72)	2,311,000 (109)
¼ seeding	145	333	5030 ‡ (105)	1,500,000 (71)

* Sixty day is not a high yielding Oat in Wales, and the grain yields of all varieties were far below the average in 1920.
† About 10 per cent. grasses and clovers.
‡ About 70 per cent. grasses and clovers.

of plants per unit of area—(counted on the ground after harvesting the mixed corn *cum* grass crop) was very much less than under the full corn crop. The half corn crop gave rise to the greatest number of established grasses and clovers. There is, therefore, evidence for thinking that a reasonably thick stand of corn allowed to ripen may actually favour the establishment of the grasses and clovers by checking a too vigorous early growth of these species, more particularly of such as Italian Rye Grass, which may have a greater smothering effect on the young seeds than would the normally developing corn crop. It does not, of course, follow that the yield in the first harvest year will necessarily be heavier from plots sown under a ripening corn crop—because the fewer and more vigorous plants which will have survived under the thin corn crop may, on account of their greater vigour, produce an equally good yield.*

* It was not possible to carry the plots sown under corn into the first harvest year for hay yields.

The results given by Rhodin and those at Aberystwyth are complementary to each other and show directions in which a ripening corn crop may be expected to influence " seeds " sown with it, both under conditions of drought and of excessive rainfall. In the case of seeds sown alone or under rape, a too luxuriant growth making for too keen competition can, of course, always be checked at will by judicious grazing, while the ill effects of corn becoming lodged must always be borne in mind.

VII. Broadcasting versus Drilling.

Increased attention has recently been given to the question of sowing seeds mixtures will a drill; Bond (3) and others in this country have cited instances of considerable success achieved by this method. Trials recently reported by Lindhard (24) are, therefore, of particular interest, very briefly stated the chief points to be noted are as follows:—

A mixture at the rate of 32 lbs. per acre was used, consisting of about 32 per cent. clovers and 68 per cent. grasses. Red, Alsike, and White Clovers, with Italian and Perennial Rye Grasses, Timothy, Cocksfoot, and Meadow Fescue were employed. The drills were about 4″ apart, and the seed sown at a depth of about an inch or a little over. The broadcast seed was covered by a harrow, followed by rolling, the drilled seed was also rolled.

Under both methods the soil establishment (by numbers) has been on the average about the same, but under the most favourable conditions the advantage has been slightly with broadcasting.

With the same rate of seeding in the case of both broadcasting and drilling, the yield from the drilled plots at each of six centres has been the heavier, giving on the average of all the trials an increase of 5 per cent. for the 1st cut in the first harvest year. A half seeding, namely 16 lbs. per acre when drilled, has, on the average, given a too open stand, and although at some centres hay crops as heavy as with the full seeding have been obtained—on the average a reduction of 7 per cent. revealed itself.

Lindhard apparently does not consider that drilling of itself necessarily ensures any greater security of establishment under unfavourable conditions than broadcasting, provided the latter procedure is supported by proper covering operations, and he emphasises the need of very vigorous rolling, particularly when the smaller seeds species are included in a mixture. He concludes rather that the undoubted benefits from drilling are primarily due to the more even distribution of the seed that it is possible to achieve by resort to this plan.

VIII. The Compounding of Seeds Mixtures.

The most extensive work with reference to actually testing different mixtures in Denmark has been concerned with two year leys and comparatively little data are available for third and fourth harvest years. In Sweden more has been done with longer duration mixtures, but an appreciable proportion of the data available do not yet go beyond the third harvest year, while very particular attention has been paid to the needs of peaty soils. In both countries *Bromus arvensis*, chiefly on account of its greater winter hardiness, is more extensively used than Italian Rye Grass as the short duration element in mixtures, and this, of course, tends to give many of the mixtures under trial a very different character to those used in this country.* Although the particularly complete data available should not be regarded as directly applicable to the needs of England and Wales, it yet throws much light on the whole question of drawing up sensible seeds mixtures, and it is from this point of view that it is proposed briefly to consider some of the more important papers.

1. The Importance of Clovers. Lindhard (12) and (19) reports on three very extensive series of seeds mixture experiments: first period, 1883—1902 with 36 mixtures at four centres; second period, 1900—1904 with 62 mixtures at four centres; and third period, 1905—1909 with 72 mixtures at five centres.

The type mixture originally drawn up by P. Nielson and at that time generally employed in Denmark for two year leys has been used as the standard. The P. Nielson mixture is approximately as follows in lbs. per acre†:—

Early Red Clover	...	6.4	39.6 per cent.
Alsike Clover	...	2.4	
White Clover	...	.4	
Cocksfoot	...	3.2	60.4 per cent.
Tall Oat Grass	...	3.2	
Timothy	...	2.4	
Meadow Fescue	...	1.2	
Perennial Rye Grass	...	2.4	
Italian Rye Grass	...	1.6	
Total	...	23.2	100.0

* The relative yielding capacity (on sum of two cuts) in the first harvest year between Perennial Rye Grass, Italian Rye Grass and *Bromus arvensis* as the result of trials conducted in Sweden by Witte (40) is as follows:—

Perennial Rye Grass	...	...	...	100
Italian Rye Grass	...	...	...	90
Bromus arvensis	...	...	...	126

This indicates the poor hardiness of Italian Rye Grass in Sweden and shows the marked superiority of *Bromus arvensis*, which latter grass would seemingly deserve trial at the higher elevations in Wales.

† This mixture was drawn up before the Late Red Clovers had been extensively tested.

The considerable contribution of clovers to the mixture is a point of some interest, and in nearly all the mixtures under test this has been maintained in the neighbourhood of 40 per cent.—which is decidedly higher than the clover contribution to many of the types of mixtures now largely employed for two years in this country—thus mixtures framed on the Cockle Park plan usually contain about 17—20 per cent. of Clovers; those recommended by Findlay for Scotland contain about 17 per cent., while mixtures in general for two years seldom exceed a 33 per cent. clover contribution.*

The earlier trials had shown that the yield from Red Clover alone may often compare very favourably with that from Red Clover with one or more grasses, while any one of the grasses grown alone will invariably be out-yielded by a grass-clover mixture. The later trials also appear to indicate that a grass grown with Red Clover frequently itself yielded more heavily than when grown alone. In consequence, and having regard to the sum of the yields from a first and second harvest year, Lindhard states that the growth from the leguminous plants should at the outset be good and that these should not be hampered by a too dense growth of grasses. This is a maxim, the soundness of which to-day probably also applies to longer duration mixtures in the composition of which Wild White Clover now plays such a large part in this country—while alike in Denmark, Sweden, England and Wales the extra late Red Clovers are becoming to be used ever more extensively for the two, three and four year leys.

Since the legumes play such an important part in the bulk produced from leys, it becomes a matter of great moment to discover a substitute for Red Clover on soils and under conditions generally where the plant can not be relied upon. Lucerne has, of course, proved successful on calcareous soils on situations too dry for Red Clover; a plant of considerable promise for soils somewhat deficient in lime or where Eel worm (*Tylenchus devastatrix*) renders Red Clover unreliable, and generally for longer duration leys appears to be Bird's Foot Trefoil (*Lotus corniculatus*), both Lindhard (20) and Witte (35) having reported results which seem to indicate the desirability of conducting similar trials, at least on the poorer soils and at the higher elevations, in Wales.

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* See *The Improvement of Grassland*, Miscellaneous Publication No. 24, and *Seed Mixtures for Grassland*, Leaflet No. 310. The Ministry of Agriculture, London.

The following statement taken from trials conducted in Denmark indicates the potential cropping power of Lotus.*

Mixtures.	*Relative yields sum of 2 cuts in the 1st and 2nd harvest years.*	*Contribution of Leguminosae in 2nd harvest year.*
Early Red Clover plus 6 grasses	100	8.3
Late Red Clover plus 6 grasses	112	19.1
Lotus plus 6 grasses	129	39.8

* Hansen and Mortensen (6), quoted by Witte (35).

Lindhard has, however, shown that Lotus, even more than Red Clover, tends to be suppressed by a too strong development of the grasses. Thus, from a mixture of 18 lbs. per acre, when Lotus contributed slightly over half of the total seeding, the yield was 5 per cent. greater than when Lotus contributed but a third to the total seeding, and when Lotus constituted ¾ of the total seeding, the yield was 12 per cent. greater.

Witte thinks it probable that Red Clover, particularly late Red Clover, would also hamper the development of Lotus, and advocates the following mixture for a 3—4 year ley, when it is desired to rely upon this leguminous plant.

Lotus	...	10.6 lbs. per acre.
Cocksfoot	...	4.4 lbs. per acre.
Meadow Fescue	...	1.7 lbs. per acre.
Timothy	...	2.6 lbs. per acre.

In Denmark and Sweden Lotus is regarded as equally suitable for cutting or grazing; it is markedly early and also develops a good aftermath.*

2. THE BEHAVIOUR OF VARIOUS GRASSES. The comparative yielding capacity of the chief grasses in the first and second harvest years when sown with Red Clover is well shown by Lindhard's results. In this country much is often made of the fact that in the first harvest year Perennial Rye Grass invariably out-yields Italian in the first cut—the Danish trials, of course, support this view, but show that when the aftermath cut is also considered Italian Rye Grass and Red Clover on the average yield as heavy a total crop as Perennial and

* Lotus was included in an eight-species mixture (only at the rate of ¾lb. per acre) which also contained Red Clover sown at Aberystwyth in 1922 and in the second harvest year (1924), although obviously placed in too keen initial competition with other legumes and with excess of grasses none the less contributed 6.4 per cent. to the hay crop (E. 53).

Red Clover. Tall Oat Grass in the first harvest year at some centres gave heavier yields with Red Clover than either of the Rye Grasses, and on the average gave crops but slightly less heavy. Cocksfoot and Meadow Fescue with early Red Clover and Timothy with late Red Clover gave good first harvest year yields, but on the average decidedly lower than the best Rye Grass *cum* Clover plots. In the second harvest year Tall Oat Grass and Clover gave the heaviest yields, Timothy and late Red Clover gave high yields—at some centres Cocksfoot and Clover out-yielded Perennial Rye Grass and Red Clover, while at others the position was reversed, Perennial Rye Grass coming out with slightly the higher average. It is in the third harvest year that Cocksfoot shows to the best advantage.

The effect of the chief grasses on the development of Red Clover is well shown by the clover contribution to the crop in the second harvest year. It is very decidedly higher with Timothy than with either Perennial Rye Grass or Tall Oat Grass or Cocksfoot. The clover contribution, however, is appreciably higher with Perennial Rye Grass than with Cocksfoot or Tall Oat Grass—Swedish trials also having shown that Cocksfoot tends to hamper the development of Red Clover.

3. Very Simple versus Relatively Complex Mixtures. Lindhard's data only afford limited scope for comparing complicated with simple mixtures—since the most complex mixtures did not exceed 7-10 species, and data are not available beyond the third harvest year. His mixtures may, however, be usefully divided into two classes: (1) Grass mixtures in which usually about six species of grasses are sown with three species of clovers, and (2) Clover mixtures in which one species of grass is sown either with Red Clover alone or with Red, Alsike and White Clover. An analysis of the extensive data available shows the comparative results given in Table IV.

The comparative yields for the first and second harvest years are based on averages obtained from the 1900-1904 and 1905-1909 data at four centres each; third harvest years only being available from two centres 1900-1904 and from one centre 1905-1909. The weed data have been obtained from the 1883-1902 series.

It will be seen from the table that in the first harvest year the clover mixtures give as high average yields as the grass mixtures, while the heaviest yielding clover mixture has always substantially out-yielded the heaviest yielding grass mixture. It seems quite evident, therefore, as Lindhard has remarked, that for a one year ley two compatible and heavy yielding species (the one a grass and

the other a clover) suitable to the conditions may be depended upon to out-yield any greater number of species compounded together. In the second and third harvest years there has been no more than about a five per cent advantage with the grass mixture, and this despite the fact that it was the early Red and not the late which was chiefly employed in the clover mixtures. The best clover mixture, however, usually yields as heavily, and sometimes slightly out-yields the best grass mixture in the second harvest year. In the third harvest year also the best clover mixture approaches very closely in yield to the best grass mixture.

TABLE IV. (1) To compare the yields (sum of hay and aftermath) from a grass mixture (7-10 species) with those from a Clover mixture (2-4) species respectively for the first, second and third harvest years. The yield from the grass mixture in each case being placed at 100. (2) To compare the yields in first harvest year with those in the second and third—the yield in the first harvest year being expressed as 100 respectively for a grass and a clover mixture (figures in brackets). (3) To show the contribution of weeds (per cent. by weight) to the crops of both grass and clover mixtures in the first, second and third harvest years.

	1st harvest year.		*2nd harvest year.*		*3rd harvest year.*	
	Relative yields.	*Per cent. weeds.*	*Relative yields.*	*Per cent. weeds.*	*Relative yields.*	*Per cent. weeds.*
Grass mixture 7—9 species	100 (100)	0.8	100 (83.6)	0.7	100 (54.7)	1.1
Clover mixture 2—4 species	100.9 (100)	1.6	95.1 (78.8)	2.2	94.7 (51.3)	5.6

Grass mixtures: Average of 14 mixtures 1900—1904.
Average of 17 mixtures 1905—1909.
Clover mixtures: Average of 6 mixtures 1900—04 Red Clover and 1 grass.
Average of 6 mixtures 1905—09 Red, Alsike, and White Clovers and 1 grass.

Practically all the grass mixtures contained Italian and Perennial Rye Grasses, Cocksfoot, Timothy, Tall Oat Grass and Meadow Fescue.

In nearly all cases Early Red Clover was used in the Clover mixtures, Late Red Clover only being employed with Timothy.

With reference to weed suppression it will be noted that in each harvest year the advantage was unmistakably with the grass mixture.*

The relative yielding capacity of grass mixtures and clover mixtures has been made the subject of a special investigation by

* Trials at Aberystwyth also show that on the average the many species mixtures tend to become less weedy than the few species ones, but there is also evidence to suggest that the addition of comparatively small amounts of Italian Rye Grass and of Wild White Clover to the clover mixture very materially assist in weed suppression.

Rhodin (28) in Sweden. The trial was an exhaustive one conducted at numerous centres, involving in all 69 plots. It was continued from 1909 to 1918, data being presented for seven harvest years on humus, clay and sandy soils. The seed rates for the clover mixtures were appreciably higher than those adopted by Lindhard, the total seeding usually being over 30 lbs. per acre.* Timothy was the only grass—usually at about 16 lbs. per acre—and was sown with Swedish late Red Clover, usually at from 7 to 10 lbs. per acre; and Alsike Clover, usually about 5 to 7 lbs. per acre—in many of the mixtures clovers contributing as much as 50 per cent to the total seeding. The grass mixtures included either 11 or 12 species, the total seeding varying between 18½ and 57 lbs. per acre—Meadow Fescue, Meadow Foxtail and Red Fescue were included on occasion up to about 9 lbs. per acre. Timothy or Cocksfoot did not exceed 3¾ lbs. per acre. The Rye Grasses were not included. The clover seedings were light, in some mixtures not exceeding 4 lbs. per acre.

The statement hereunder gives a summary of the chief results, based on hay cuts, aftermath data only having been obtained on a limited number of plots.

	Harvest years.						
	1st	*2nd*	*3rd*	*4th*	*5th*	*6th*	*7th*
Clover mixture: relative yields	100	100	100	100	100	100	100
Grass mixture:	86.9	85.5	90.5	97.0	95.2	84.7	94.6

	Average of all trials for all harvest years.
Clover mixture:	100.0
Grass mixture:	88.5

The centres at which aftermath weights were obtained also showed to the advantage of the clover mixture. It is thus apparent that over as long as a seven year period the advantage was very considerably with the clover mixtures, although these were tested against complex mixtures which were deemed to be admirably suited to the conditions. It should be pointed out that the climate was somewhat severe and dry and that the Danish and Swedish trials alike tend to show that grasses are affected more adversely than clovers by conditions of drought, or at least attain to their fullest development in regions of considerable humidity.

It would appear that in the case of these trials also, unsown species become more abundant in the clover mixtures than in the grass mixtures.

Trials conducted by Witte and Nystrom (46) with seven mixtures at one centre, and with eight at another, show in the former case the simple Clover-Timothy mixture giving slightly the highest yield over

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* Lindhard's clover mixtures totalled about 20 lbs. and his Timothy contribution was usually about 6½ lbs., compared to Rhodin's 16 lbs.

five harvest years, while in the latter case the Clover-Timothy mixture was only substantially out-yielded by one of the more complex mixtures—a mixture which, however, consisted of but seven species, and had a Timothy contribution of 40 per cent and a Clover contribution of 30 per cent. In both cases the unsown and weed contribution on the plots sown with the clover mixtures was at least twice as large as on those with the grass mixtures.

Glaerum (5) reports interesting results from trials somewhat similar to those conducted by Rhodin. These trials were laid out on upland farms in Norway in 1912 and data are presented for four harvest years. Small plots replicated four times on each of 29 farms distributed around three main centres constituted the experiment.

Late Flowering Red Clover (four different strains), Timothy and Cocksfoot were sown alone. The Clover mixtures consisted of Late Flowering Red Clover, 20-50 per cent, and Timothy, 50-80 per cent, and in one instance an addition of 10 per cent Alsike.

The grass alone mixtures consisted of Cocksfoot, 20-30 per cent, Timothy, 20-40 per cent, Meadow Fescue, 20-30 per cent, Perennial Rye Grass, 0-10 per cent, other species 0-30 per cent. The grass mixture (Clovers plus 4-7 species of grasses) consisted of Late Flowering Red Clover, 10 per cent, Alsike Clover, 5-20 per cent (total Clovers 15-30 per cent), Timothy, 15-20 per cent, Meadow Fescue, 20 per cent, Cocksfoot, 20 per cent, Perennial Rye Grass, 0.10 per cent, other grasses, 10-20 per cent. The essential results are given in Tables V and VI.

TABLE V. To compare the yields for the sum of four harvest years from plots sown (1) with Timothy alone, (2) with Cocksfoot alone, (3) with Timothy plus Late Flowering Red Clover (expressed as 100), (4) with 6-7 species of Grass without Clovers, and (5) with Red Clover, Alsike Clover plus 6-7 species of grasses. The average percentage of unsown species contributing to the harvest of the four harvest years is also shown.

Sowing.	*Relative yield.*	*Per cent. unsown species.*
Timothy plus Late Flowering Red Clover ...	100.0	6.9
Late Flowering Red Clover and Alsike, plus 6-7 species of grasses ...		8.5
Timothy alone ...	91.2	9.0
Late Flowering Red Clover alone	88.9	11.5†
	—*	
6-7 species of grasses and no Clovers ...	74.6	8.5
Cocksfoot alone ...	58.2	11.3

* Average results for Late Flowering Red Clover alone can not be given as on some of the fields the stand was not satisfactory. On the fields with moderate and good stands, however, Late Flowering Red Clover alone usually out-yielded Timothy alone, and on some fields actually gave the highest aggregate yield of all the plots over the four year period.

† Weed contribution on plots with moderate or good stands.

TABLE VI. To show the contribution made by the chief species to the hay crop of the first three harvest years in the case of Timothy plus Clover and the Clover plus seven species of grasses mixtures.

Mixture.	*Harvest year.*	*Per cent. contribution.* *Red Clover.*	*Timothy.*	*Meadow Fescue.*	*Cocksfoot.*	*Per Rye Grass.*
Timothy plus Red Clover	1	29.6	67.1	—	—	—
	2	36.3	60.9	—	—	—
	3	23.0	68.3	—	—	—
Seven grasses plus Red Clover and Alsike	1	23.0	36.5	11.0	4.0	7.0
	2	42.1	35.6	13.7	5.1	trace
	3	9.2	40.0	17.1	27.1	trace

It may be stated that on the average, just as in Denmark, Late Flowering Red Clover alone out-yielded a grass alone, but that a grass (Timothy) plus Late Flowering Red Clover yields a safer and heavier crop than clover alone. The chief interest, however, lies in the fact that, just as in Sweden, the Timothy-Late Flowering Red Clover mixture came out with the highest yield over the four year period, and also gave heavier yields than the grass mixture (7-9 species) on the vast majority of individual fields. In this series of trials it will be noted that the clover mixture kept itself slightly cleaner of unsown species than the grass mixture, Cocksfoot alone and Red Clover alone being the least satisfactory in this respect. It will be apparent from reference to Table VI that the Late Flowering Red Clover in the clover mixtures maintained itself at a remarkably high level into the third harvest year, and this fact will of course have materially contributed to the success of the Timothy-Clover mixture, while in the more complicated mixture (with a smaller clover seeding) although the Red Clover was abundant in the second year it had fallen very considerably by the third harvest year. Timothy has also maintained itself very well for three harvest years, so that the two species have obviously been well adapted to the conditions, which is also indicated by the high relative position taken by each species when sown alone.

The superiority of Timothy over Cocksfoot is of interest and shows how much more hardy and trustworthy the former species is for severe conditions—the success of Timothy in both the Norwegian

and Swedish trials should not be lost sight of by the hill farmer in Wales; the relative hardiness of this species and of genuine Late Flowering Red Clover probably renders them particularly applicable for temporary leys at the higher elevations.*

All the trials under review agree in showing that Cocksfoot frequently tends to increase considerably in amount in the third harvest year, while Perennial Rye Grass and Meadow Fescue usually fall off very appreciably after the third harvest year, and this is frequently true of Timothy. The following figures given by Rhodin are fairly typical of Timothy:—1st year, 50 per cent; 2nd year, 28 per cent; 3rd year, 40 per cent; 4th year, 9½ per cent; 5th year, 7 per cent. Osvald (26), however, shows Timothy maintaining itself at 19 per cent in the 5th harvest year, but it has fallen to 2 per cent by the 7th.

Meadow Foxtail is a species which tends to increase considerably in amount after the third harvest year. In Osvald's trials it did not reach its highest contribution until the 5th year, while *Poa pratensis* also gains ground steadily, usually not reaching its maximum till after the fifth harvest year.

The seed rates of Cocksfoot, Meadow Fescue and the other grasses have not been varied over a wide margin in the trials under review, and for Cocksfoot has seldom exceeded a 12 per cent contribution. This must be borne in mind, for in this country the Cocksfoot seeding (for 3-5 year leys) is frequently over 20 per cent of the whole mixture, when the contribution to the hay of the second harvest year is often very considerable. Lindhard's trials, on the average, however, show appreciably better results from Cocksfoot when included in grass mixtures at the rate of about 4¾ lbs. per acre (the highest contribution) than when not exceeding 3¼ lbs. per acre.

4. THE YIELDS OF DIFFERENT HARVEST YEARS COMPARED. Witte and also Rhodin point out that the climatic conditions have almost a dominating influence on the yields of leys and that with a good mixture there need be no necessary great falling off as the ley becomes older. If, however, the results given by Lindhard, Glaerum

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* In the more northern States of America and in Canada, Timothy is, of course, far more largely used than Cocksfoot (Orchard Grass). It is, however, realised in America that Cocksfoot has many decided advantages over Timothy and hardier strains are being sought, while for Swedish conditions Rhodin states that if the breeder could produce hardier strains of Cocksfoot, which would also ripen later, Timothy would give place to Cocksfoot in the Clover leys. It is noteworthy that, despite the small contributions of Timothy to the mixtures used by hill farmers in Wales, this species is often to be seen in considerable amount on such leys.

and Osvald, together with those of Witte and Rhodin, are considered as a whole it appears to be pretty certain that, on the average, leys in their first and second harvest years will tend to out-yield those in their third and fourth harvest years, while a further fall may be expected in the sixth year; but it is evident that with a suitable mixture and rational manurial treatment decreases in productivity of the order of 20 to 50 per cent, such as are all too frequent in Wales, are by no means inevitable.

5. THE INFLUENCE OF SHORT DURATION GRASSES WHEN INCLUDED IN MIXTURES FOR LONG DURATION LEYS. The influence of a short duration grass like Italian Rye Grass on the yield of four-five year leys in the second and subsequent harvest years is a much debated subject in this country. Lindhard (9), in his remarks concerning the theoretical foundation for the composition of seed mixtures, states that in drawing up a mixture particular attention must be paid to the rate of seeding of the species which will dominate the ley's first year. He considers that Italian Rye Grass and *Bromus arvensis* must be used with caution in mixtures for more permanent leys. He points out, moreover, that an increase in the total rate of seeding (even when the proportions are kept the same) will occasion an increased yield from the dominant species, which will compete the more unfavourably with the species less able to establish themselves and which are being relied upon for the later harvest years. This a-view which one of the present writers has always inclined towards. Recently, however, Witte (43) quotes Basse and Mentz (2), who show that in certain circumstances, at all events, not inconsiderable additions of Italian Rye Grass or *Bromus arvensis* have been without effect on the yield in subsequent years. The experiments were conducted on peaty soil in Jutland.* The basal mixture was as follows in lbs. per acre:—

Meadow Foxtail	8.0 lbs.
Timothy	3.2 lbs.
Meadow Fescue	6.5 lbs.
Rough Stalked Meadow Grass	1.6 lbs.
White Clover	.4 lbs.
Vicia cracca	.4 lbs.
Lathyrus pratensis	.4 lbs.
	20.5 lbs.

To this mixture on different plots was added four amounts of Italian Rye Grass, varying from 1.7 to 7.1 lbs. per acre, and on other

* Witte does not state whether the mixture was sown under corn or not, this, as previously shown, might make a considerable difference. It has not been possible at present to consult the original paper.

plots *Bromus arvensis* in four amounts, varying from ¾ lb. to 8 lbs. per acre. It is stated that in both the case of *Bromus arvensis* and Italian Rye Grass, and when added in the largest amounts, although these appreciably augmented the yield in the first harvest year they did not reduce the yield in the second to the eighth harvest years. The following relative statement showing the effect of *Bromus arvensis* may be regarded as typical:—

	1st harvest year.	*Average of 2nd, 3rd, 4th, 5th, 6th, 7th and 8th harvest years.*
Without *Bromus arvensis* ...	100	100
With *Bromus arvensis* ...	134	100

Witte emphasises the fact that the experiment was concerned with mixtures consisting mainly of grasses, and he states that in mixtures for ordinary soils in which clover species predominate a too large sowing of the short duration grasses tends to displace the clovers.

The rate of sowing experiment conducted at Aberystwyth, and previously referred to, appears to throw further light on this question. It has been shown that the least number of established grass and clover plants was obtained on the plots sown with ¼ seeding of oats. On these plots the Italian Rye Grass grew very luxuriantly during the seeding year, while under the full oat seeding neither Italian Rye Grass, Cocksfoot or Red Clover made vigorous growth. It is of interest, therefore, in the case of the mixture sown at the rate of 20 lbs. per acre, to compare the number of plants of Cocksfoot and of Red Clover per unit of area found on (1) the plots on which Italian Rye Grass was suppressed, i.e., under the full seeding of oats, and (2) on those on which Italian Rye Grass made vigorous growth, i.e., under the ¼ seeding of oats:—

To show the number of plants per acre after the removal of the nurse crop in the seeding year:—

	Cocksfoot.	*Red Clover.*
Under full seeding of Oats ...	965000	592000
Under ¼ seeding of Oats ...	659000	226000

The above figures speak for themselves. It is also interesting to note that in the case of the plots sown under the quarter oat crop the number of Red Clover plants was actually least on the full mixture plots (10 lb. Italian Rye Grass, 5 lb. Cocksfoot and 5 lb. Red Clover) and most on the ¾ mixture plots. That is to say that

3¾ lb of Red Clover in competition with 7½ lb. of Italian Rye Grass and 3¾ lb of Cocksfoot gave rise to a greater number of established plants in the autumn of the seeding year than 5 lb. of Red Clover in competition with 10 lb. Italian Rye Grass and 5lb. of Cocksfoot.

The above facts seem pretty clearly to indicate that considerable sowings of Italian Rye Grass, in cases where this species can develop freely during the seeding year, have an undoubted depressing effect on the number of plants of Red Clover and of Cocksfoot which will have established themselves by the autumn of the seeding year. It is evident, however, from the trials under review that differences in the aggregate number of plants representing the sown species resulting either from different seed rates or different " nurse " rates level up to a certain extent by the first harvest year, and to a more considerable extent by the second harvest year. This, as Lindhard's evidence previously discussed would seem to suggest, is probably due to the rate of mortality being high for any particular species in proportion as the number of plants per unit of area of that species is considerable.

Lindhard (8) has shown, moreover, in the case of Cocksfoot, Timothy, Meadow Foxtail and Meadow Fescue, for instance, that there is a decided tendency for the weight of the individual plant to increase very considerably in the second and third harvest years over that given in the first, and, of course, the extent of this increase will be influenced by the degree of crowding. It is thus apparent that there are many causes which may fairly rapidly compensate for comparatively poor initial establishment, and that provided Italian Rye Grass has not been responsible for creating a too poor initial stand of the more lasting grasses and clovers, the sufficiency of larger plants of these may yield as heavily per unit of area as an excess of smaller plants.

In view of the undoubted ability of Italian Rye Grass to suppress weeds, and its great value for winter grazing, it is very important that its effect on the other components of a mixture should be definitely established, and that the relation of the nurse crop to these influences should also be investigated.

IX. Mixtures for Peaty Soils.

Basse and Mentz (2), in their trials above referred to, have shown the benefit to be gained by adding sand to peaty soils. One series of plots was sanded (at the rate of 7,145 cubic feet per acre), when, taking the average of all the seeds mixtures over the eight harvest years, the yields from the sanded plots showed an increase of about

22 per cent over the non-sanded. Witte (44) quotes Simola (29), who conducted trials for a number of years at the Experiment Station of the Finnish Moor Culture Association and who tested the effect of additions of both sand and clay on the results from ten different seeds mixtures. Clay was applied in amounts from 1,429 to 5,716 cubic feet per acre, and sand from 2,858 to 5,716. Average results from typical dressings and from all the mixtures over seven harvest years are indicated by the relative statement hereunder:—

Dressing.	*Relative yields.*	
	Clay.	*Sand.*
No sand or clay ...	100	100
2.858 cubic feet per acre ...	**150**	116
5,716 cubic feet per acre ...	172	130

It will be noted that better results were obtained with clay than with sand, and that in both cases the heaviest dressings were responsible for the highest yields.

The mixtures used in no case exceeded eight species, of which the most successful on the basis of average results from the sum of eight harvest years were as follows:—

Mixture in lbs. per acre.	*Relative Yields.*
Timothy alone at 26.7 lbs.	100
Timothy, 17.8; Cocksfoot, 4.4; Meadow Fascue, 4.4; Red Clover, 2.6; and Alsike, 6.2	100
Timothy, 17.8; Red Clover, 6.2; and Alsike, 2.6	102
Timothy, 8.7; Meadow Foxtail, 4.4; Meadow Fascue, 4.4; Smooth Stalked Meadow Grass, 4.4; Crested Dog's Tail, 3.5; Red Clover, 6.2; and Alsike, 2.6	110

It is noteworthy that the highest yielding plots were in all cases those to which Timothy had contributed in large measure to the mixture, and that the Timothy-Clover plot was only out-yielded by one of the more complex mixtures, the species in addition to Timothy contributing to the high yield of which latter plot had been Meadow Foxtail and Smooth Stalked Meadow Grass, which maintained themselves exceedingly well through the duration of the ley. Cocksfoot and Meadow Fescue did not yield particularly well, while the Rye Grasses, Crested Dog's Tail, Sweet Vernal Grass and *Agrostis stolonifera*, gave very poor results. *Phalaris arundinacea* and *Festuca arundinacea* both gave decidedly satisfactory yields. Witte and Nystrom (46), conducting trials over a five year period found that Swedish Late Flowering Red Clover and Swedish Alsike were the most satisfactory legumes, and of the grasses, in addition to those mentioned above, *Poa Serotina* and *Festuca rubra* gave excellent

yields; *Festuca pratensis* was only satisfactory in the first harvest year.

Osvald (26), in a very interesting paper, gives results obtained on peat for leys in first to fifth harvest years, in eighth and 25th harvest years. He shows that it is possible to obtain high yields, winter hardiness and permanency with resort to comparatively few species. Osvald has estimated the grazing value of the swards by ascertaining the "stem shoot," "leaf shoot" relationship, and although he does not appear to have tested clover mixtures (clovers and one grass) against grass mixtures, he is a strong advocate of the simple mixture. He finds that Timothy and Alsike Clover admirably cater for good hay yields in the first years and White Clover, Meadow Foxtail and Smooth Stalked Meadow Grass for grazing in the subsequent years; and in consequence would seem to have obtained excellent results with a mixture drawn up in the following proportions:—

Timothy	35 per cent.
Meadow Foxtail	10 per cent.
Meadow Fescue	20 per cent.
Smooth Stalked Meadow Grass	5 per cent.
Alsike Clover	20 per cent.
White Clover	10 per cent.

It would seem evident from a consideration of all the trials that Timothy, Meadow Foxtail and Smooth Stalked Meadow Grass (provided drainage has been adequate) should perhaps be regarded as the three most valuable grasses for peaty soils, while *Poa Serotina, Festuca rubra* and "Jaedersk" Rye Grass are also important species for such situations. There is evidence that a suitable strain of Red Clover may give results as good as or better than Alsike, though Alsike is certainly to be regarded as a reliable Clover for peat, while White Clover is also an important ingredient to the swards on such soils.

X. General Conclusions.

Perhaps the outstanding lesson to be learned from a critical examination of the literature here dealt with is the immense importance of conducting trials on a uniform plan at a great number of centres. It is painfully obvious that the difficult problems affecting the correct choice of seeds mixtures can never be solved by independent trials, no matter how numerous, each conducted on a different plan and without reference to the elucidation of any particular fundamental problem.

The necessity of substantiating all seeds mixture work with careful botanical analyses is also abundantly shown, as is the need for con-

centrating attention on the growth habits of various species under varied conditions.

In regard to actual mixtures, the prominence given to clovers even in the case of longer duration leys appears to be justified, and nothing is of more significance than the results obtained by the Danish, Swedish and Norwegian investigators alike with reliable strains of Late Flowering Red Clover, which, in addition to the keep they provide in the second and third harvest years, would seem to react very favourably on the development and yielding ability of the grasses.

The achievements from simple Clover-one-grass-mixtures have been sufficiently noteworthy to call for careful trials in this country on similar lines. It is, of course, obvious that the addition of several grasses to clovers renders a mixture safer and better suited to a wide range of conditions, but with a proper knowledge of any particular set of conditions it has been shown that a large number of species appears quite unnecessary. Under the humid conditions of Wales, grasses, of course, succeed particularly well, but this is not necessarily a sufficient argument for sowing a large number of species.

In conclusion, it is perhaps desirable to make a suggestion as to seeds mixtures for 3—5 year leys likely to be suitable to Welsh conditions on the basis of the results here reviewed and aided by a not inconsiderable experience of Welsh conditions and Welsh grasslands.

The clover mixture of the Swedish authors is likely to exert an insufficient retarding effect on weeds and bent, and could probably not be depended upon to develop a sufficiently good grazing sward. The former defect should be counteracted by the addition of Italian Rye Grass, tentatively a maximum seeding not exceeding 4 lbs. is suggested, the latter defect can almost certainly be met by adding Wild White Clover and Rough Stalked Meadow Grass. The mixture would then take the following general form—the higher seed rates being applicable to poorer conditions generally and to the higher elevations:—

	Italian Rye Grass	2-- 4 lbs.	60—64 per cent.
One of these four grasses according to the conditions.	Timothy	10--12 lbs.	
	or		
	Cocksfoot	8--10 lbs.	
	or		
	Tall Oat Grass	14 lbs.	
	or		
	Meadow Fescue	10--12 lbs.	
	Rough Stalked Meadow Grass	1½-- 2 lbs.	
	Extra Late Flowering Red Clover	5-- 8 lbs.	30—36 per cent.
	Wild White Clover	2-- 3 lbs.	

The above type of mixture would almost certainly repay exhaustive trial in contrast with those of a more complicated nature normally employed. Timothy would be relied upon on peaty soils and at the higher elevations; Timothy or Cocksfoot under average Welsh conditions; Meadow Fescue on fields of exceptionally high fertility. On Peat a further modification suggested would be the substitution of Smooth Stalked Meadow Grass for Rough Stalked and of 10 lbs., of Meadow Foxtail for the 2—4 lbs., Italian Rye Grass.

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THE PRODUCTION OF GREEN CROPS ON ARABLE LAND FOR DAIRY COWS.

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Owing to the fact that most land is capable of producing more food per acre when under the plough than when under grass, the production of green crops on arable land has received much attention of late from the point of view both of supplementing the grass supply on heavily stocked farms and also of replacing a large proportion of grassland, with a view of increasing the stock-holding capacity of farms and of the country as a whole. It is urged in some quarters that this system of farming, *i.e.*, arable stock farming, might possibly provide a key to agricultural prosperity in this country. However, this article will be devoted to the former aspect, viz., the growth of green crops as a supplement to the grass supply; the other aspect, namely, that of substituting a succession of green crops for grass is a subject for organised and extensive research, and, under ordinary conditions as to prices and climate, "arable stock farming" to-day must be regarded as a speculative type of farming.

Advantages.

It has long been the custom in some districts to grow vetches, or a mixture of vetches and oats for working horses and for indoor stock during the summer months, and through the choice of suitable crops and times of sowing, it is now possible to provide a series of green soiling crops suitable for dairy cows and other stock from the middle of June until the end of October. On the majority of farms, particularly the larger farms, the grass supply is sufficient in a normal season, but on heavily stocked farms, such as small dairy farms situated in the neighbourhood of towns, the grass area is never excessive, and in a dry summer provision in the way of green crops proves invaluable. On such farms the growing of crops which provide a quantity of green food with a fair degree of certainty makes it possible to keep a larger head of stock. The system may also be regarded as a form of insurance against a dry summer, since the autumn and early spring sowings rarely fail to provide a good cut of green food however dry the summer is. In addition, a considerable reduction in the cake bill is affected since the feeding of these crops makes it unnecessary to cake feed during the grass season; when the grass begins to deteriorate in quality from about the middle of July it is necessary to supplement it either with cake

or with green food in order to keep up the flow of milk. The provision of an ample supply of such crops has the additional advantage that in a year when the grass supply is abundant, such as this year, these crops may be utilised either by making into hay or by allowing to mature for harvesting and thrashing. It should be mentioned that when making hay from mixtures containing peas or vetches great care must be taken to prevent mouldiness in the stack; the hay should be allowed to get much drier than is the case with ordinary hay and should be too dry to create heating in the stack. A good method of ensuring the prevention of mouldiness is to allow the hay to stand in cocks for a week or ten days or to mix the hay, pea and oat or vetch and oat as the case may be, with straw in making the stack.

Experimental Work in North Wales.

Investigations on the subject of providing a series of green crops during the summer months have been carried out at the College Farm of the University College of North Wales, Bangor, and in the associated counties during the last few years, interest in the subject having been stimulated by the difficulty of maintaining the usual head of farm stock during the latter part of the war, when it was difficult to purchase concentrated feeding stuffs in any quantity and when the area of grass land had to be considerably diminished in order to produce grain crops. The experiments carried out had, as their object, the provision (from arable land) of heavy crops of nutritious and palatable green crops from as early as possible in spring until the end of the grass season. It has not been found practicable to provide a useful green crop before the spring growth of grass; autumn sown mixtures containing rye proved unsatisfactory because, while they were earlier than other mixtures their period of usefulness was very short owing to the rapidity with which they attained maturity when the growing weather set in, with the result that if not used up quickly they soon became too hard and fibrous to be readily eaten by stock. Crimson Clover was included in autumn sown mixtures in the hope that owing to its quick growing habit it would provide early growth in spring, thus providing with the rye an early cut of green food; this plant, however, did not successfully resist the winter conditions, and its contribution to the crop was very small.

Experiments with mixtures of oats and vetches with a view to providing green food from about the middle of June were more successful, and as a result of extensive trials it is possible to recommend suitable mixtures. Vetches are recommended in pre-

ference to peas, owing to the fact that the latter are not sufficiently hardy to stand our average winter, thus being unsuitable for the autumn sown mixture and also because, contrary to expectation, vetches are more readily eaten than peas by all farm stock. A mixture of oats and vetches sown in autumn provides a heavy crop (averaging 12 tons per acre) of green food from the middle of June till near the middle of July, depending, of course, on the season. In an early season the crop would provide cuts from the middle of June until the middle of July and would be too near maturity for use as a green soiling crop after this date; in a late season, however, the same mixture would not give a cut of any weight before the end of June, but would be in a suitable condition for green soiling throughout July. This crop may be followed by rape, turnips or kale, or it may be bastard fallowed if it is desired to clean the ground. For the next cut, a mixture of oats and vetches sown in April has been found very satisfactory, producing cuts up to the end of July or the middle of August, depending on the lateness of the season. The inclusion of 30 lbs. per acre of Italian Rye Grass in this mixture enables a second cut to be taken in September. In order to provide for August a mixture of oats and vetches should be sown about the end of May or beginning of June.

The provision of a green forage crop, apart from aftermath, for September is difficult under average Welsh conditions. In the S.E. counties of England maize gives a heavy cut of nutritious and palatable food during this month, but experiments carried out at the University College of North Wales show this crop to be very uncertain under the climatic conditions ruling in North Wales. During October, Early Drumhead cabbage sown in May gives a useful crop which can be grown very economically by sowing from a drill and singling as with an ordinary root crop. This avoids the expense of transplanting and also the risk of losing the crop when this operation is carried out by men inexperienced in the work.

Recommendations as result of experimental work:—

A.	4 bush. (Winter) Oats 1½ „ (Winter) Vetches	per acre sown in Autumn. Ready from middle of June to middle of July or later, depending on season. Followed by rape, kale or white turnips for autumn use, or land may be bastard fallowed.
B.	4 bush. Oats (strong strawed variety) 1½ „ Vetches (Spring) 30 lbs. Italian Rye Grass	per acre. Sown in April. Ready after mixture A. The Italian Rye Grass and 2nd growth of Vetches provides a second cut in September.
C.	4 bush. Oats (late, very leafy variety) 1½ „ Vetches	per acre. Sown end of May or beginning of June to be ready after mixture B.

D. Early Drumhead cabbage	... Sown as early in May as possible and ready for carting out latter part of September or October. In order to economise in cabbage seed, this may be mixed with turnip seed before drilling and only cabbage plants left when thinning.

Manuring and Place in Rotation.

These crops generally occupy the same position in the rotation as a root crop. Green crops containing Vetches or peas make excellent smothering crops and are cut before most of the annual weeds have shed their seed, so that if only a moderate crop were obtained, it would not allow of the multiplication of annuals such as Charlock, even though it might not be sufficiently thick to check couch grass. As stated above, the autumn sown mixtures are cut in time to allow the ground to be bastard fallowed, though on the heavier classes of soils this is often rendered impossible in a dry summer owing to the hardness of the ground. If the land is considered to be sufficiently clean, and has a texture suitable for folding, a catch crop such as rape or white turnips may be taken instead of a bastard fallow; these crops prove useful for fattening mountain wethers besides making considerable addition to the fertility of the soil. It is probable that except on the poorer classes of soils the growing of a well manured green crop containing leguminous plants such as vetches or peas, which result in an addition to the store of nitrogen in the soil, followed by a catch crop which is folded off, would result in the laying of the subsequent corn crop, and attention would have to be paid to selecting a strong strawed variety of cereal to follow the green and catch crop.

It is generally held that vetches may be grown continuously on the same ground, a factor which is of importance where it is desired to grow these crops in a field near the homestead in order to reduce to a minimum the labour of carting; this view is upheld by the experience of those farmers who grow these crops for ensilage.

In manuring green crops, manures tending to give an increase in stem and leaf should be used. Farmyard manure or quick acting nitrogenous manures are essential, and if the ground is to carry these same crops continuously, or if no other manuring is given in the course of the rotation, a dressing of 4 cwts. super-phosphate or 5 cwts. of basic slag (30 per cent.) should be given in addition. The farmyard manure is spread on the stubble before ploughing and, in the case of the autumn sown mixture, it is important to sow early in order to give the crop a firm hold before winter.

The Feeding of Green Crops.

Quantities up to 100 lbs. a day may be given to cows, the quantity depending on the quantity of grass available. It will be found more economical to feed in mangers or hay racks than to spread out on a field, since the waste through trampling is considerable, and in most cases the cows will be able to consume sufficient while being milked.

The labour of cutting and carting is mainly responsible for the limited use of green soiling crops, except on the larger intensive farms where there is a man available for odd jobs. In cases where there is difficulty in sparing a man and horse each day, the green food may be cut every two days, especially if cut when wet with dew or rain, since the crop does not tend to heat so quickly under these conditions.

Summary.

(1) The growing of green soiling crops on arable land with the object of supplementing the grass supply enables a farmer to

(*a*) Insure against the effects of a dry summer,

(*b*) or to keep more stock during summer,

(*c*) or to reserve more land for hay, thus keeping more stock over winter.

(*d*) Cut down his summer cake bill.

(2) Mixtures of oats and vetches and also drumhead cabbages are the most suitable crops for these purposes.

(3) If all or part of the oat and vetch crops are not needed owing to an abundant grass supply, they may be made into hay or silage or may be allowed to mature for thrashing.

(4) The autumn sown and in some cases the early spring sown crop of oats and vetches is cleared in time to enable a good crop of rape to be grown for feeding off in the autumn; this is particularly useful where mountain wethers are to be finished. In the event of the land not being clean, it may be "bastard fallowed" after clearing the oats and vetches.

NATURAL CROSSING IN WHEAT.

By T. J. Jenkin, M.Sc.,

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It has now been definitely established that under certain conditions and in the case of certain varieties, natural crossing may occur in wheat.

Hayes[1] quotes several instances and gives results obtained within his own experience.

Hilgendorf[2] has also met with cases, and his investigations appear to show that at certain low temperatures the anthers may be killed while the stigmas and ovaries remain unaffected. As a consequence, these often become fertilised through cross pollination.

In effect, Hilgendorf's results appear to be similar to those obtained by Leighty and Hutcheson,[3] who found that up to 52 per cent. of emasculated wheat florets might become fertilised unless protected from cross pollination. There is, however, this difference: that in Leighty and Hutcheson's results it is not known to what extent the mechanical interference with the florets during emasculation may have rendered them more liable to cross pollination. If this interferes with the natural functioning of the paleae, then the results obtained may have been to a great extent artificial.

Garber and Quesenberry[4] also quote a number of recorded instances of natural crossing, and give results obtained by themselves. These results are particularly interesting, since they were obtained by methods very similar to those used in obtaining the data presently to be referred to.

Yet, in this country, very few instances of natural crossing in wheat have been recorded, and even quite recently Engledow[5] states: "Natural cross-pollination is rare in wheat, barley, and oats. Practically all the recorded cases have occurred in warm climates. In England, the non-occurrence of the phenomenon is usually

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1 Hayes, H.K. "Natural Cross-Pollination in Wheat." *Am. Journ. Agron.*, 10 (1918), pp. 120—122.

2 Hilgendorf, F.W. "Natural Self-Fertilization of Wheat on a Large Scale." *Trans. New Zealand Institute*, 54, pp. 574—576.

3 Leighty, C. E. and Hutcheson, T.B. "On the Blooming and Fertilization of Wheat Flowers." *Am. Journ. Agron.*, 11 (1919), pp. 143—162.

4 Garber, R. J. and Quesenberry, K. S. "Natural Crossing in Winter Wheat." *Am. Journ. Agron.*, 15 (1923), pp. 508—512.

5 Engledow, F. L. "Inheritance in Barley." *Journ. Genetics*, 14, No. 1, Ap. 1924, p. 85.

assumed in genetic work and experience has justified this statement. Nevertheless there exist in this country a small number of wheat forms whose origin must be attributed to natural crossing." This statement alone is sufficient to justify the publication of the present results.

That climate may have some influence appears to be shown by Hilgendorf's work, while Engledow appears to consider a warm climate as conducive to natural cross-pollination. Nilsson-Ehle,[6] on the other hand, has found that some varieties are more liable than others, and, comparing the results given below with the statement made by Engledow, while at the same time keeping in mind the moister and cooler summer weather of West Wales as compared with Cambridge, it would seem that in this country the variety is of greater importance than climatic conditions.

Evidence of Natural Crossing.

What appear to be the results of natural crossing have been observed in two wheat varieties at the Welsh Plant Breeding Station. These two varieties are "Gwenith Coch Bach" (apparently a local North Wales synonym for Red Fife) and "Hen Gymro." The former has only been studied to a very limited extent, and the results obtained are therefore insufficient for useful discussion. It should be borne in mind also that the results from "Hen Gymro" were incidentally obtained and not from *ad hoc* experiments, so that the exact amount of natural crossing that occurs in the variety has not been determined.

"Hen Gymro" is an old land variety of winter wheat still grown to a considerable extent, particularly in Cardiganshire. It is often claimed that, taking one season with another, it gives better average yields than the newer varieties. The validity or otherwise of this claim has not been thoroughly tested by means of critical experiments, but it is of interest in view of the results here to be discussed.

Two samples of "Hen Gymro" seed received at the Welsh Plant Breeding Station produced crops in 1920. In general, the ears agreed throughout in being relatively long, narrow, and lax, although it was evident that even in this respect, there was some variation. In other ear characters, there was very marked variation. Thus, while the majority of the ears in each lot were red, smooth glumed and not fully bearded, white glumed, rough glumed and fully bearded ears were also present, together with all the possible re-combinations of these three pairs of contrasting characters.

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[6] Quoted by Hayes, *loc cit.*

It should be further pointed out that in "Hen Gymro" there appears to be two types of true-breeding red glumes, one a shade deeper than the other. In the case of the paler type, it is sometimes difficult, when the climatic conditions are adverse at ripening, with certainty to differentiate between white glumes and the intermediate resulting from a cross between white and pale red. This difficulty is still greater when the glumes are also hairy, and these facts may have affected the present results to a very slight degree.

In "Hen Gymro," there are also true-breeding semi-bearded types, but for present purposes, all those which are not fully bearded are contrasted with fully-bearded types from which they are easily distinguished. Similarly, a true-breeding type in which the glumes are semi-hairy has been met with.

From amongst the 1920 crop already referred to, 209 individual ears were selected, for the purpose of raising pure lines. The selection was not, strictly speaking, at random, owing to (1) a fair number of ears of each distinct type were selected irrespective of the proportions in which these different types occurred in the entire crop, (2) the best developed ears of each type were selected.

Twenty-three grains from each selected ear were sown in a bird-proof cage on the ear-to-row method (Experiment C 29, 1920-21). Germination and growth up to a certain point were satisfactory, although in certain lots but few plants were obtained. It is possible that in some such lots the number of plants was too small to give positive results. Part of the cage also suffered severely from drought so that many lots ripened abnormally, but this would affect chiefly glume and straw colour and doubtful cases due to this have not been included in the results.

When the ears appeared, it was found that some lots were mixed in respect of beardedness and hairiness of glumes. As ripening advanced, certain lots were also found to be mixed in respect of straw colour, while others were either all red-strawed or all golden-strawed.* Where the conditions in the cage were favourable, straw colour developed beautifully, but in the part affected by drought, forced ripening interfered so that full results were not obtained for this character. Later experience has shown that the conditions necessary for full development of straw colour are rarely obtained at Aberystwyth.

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* With reference to straw colour, the present results appear definitely to show that red colour is dominant over golden and that this character is different from and independent of glume and grain colour, since grain colour was red throughout.

When ripe, certain lots again were found to be mixtures of white and red glumed plants. Further observation showed that the mixed lots were of two main types—

A. Lots in which the majority of the plants exhibited the dominant of a pair of contrasting characters.

B. Lots in which the majority of plants exhibited the recessive of a pair of contrasting characters.

Since these two categories appear to indicate either two distinct phenomena or two phases of the same phenomenon, they will be discussed separately.

A. *Lots in which the majority of the plants exhibited the dominant of a pair of contrasting characters.*

TABLE I.—Showing Results placed under Category A: Ear-rows, which showed a majority of Plants exhibiting the Dominant of a Contrasting Pair of Characters.

Station Number.	* Type of Parent Ear	Character of Progeny Plants and their number.							
		Glume* Colour.		Hairiness* of Glumes.		* Beardedness		Straw* Colour.	
Ca		R	r	H	h	B	b	G	g
143	RBh	13	7	—	—	15	5	—	—
145	RBh	13	6	—	—	—	—	14	5
154	RBH	—	—	15	3	—	—	—	—
167	rBh	—	—	—	—	16	4	17	3
180	rBH	—	—	16	3	—	—	—	—
227	rbH	—	—	6	1	—	—	—	—
228	rbH	—	—	5	2	—	—	—	—
248	RBH	16	3	12	7	—	—	14	5
273	rBH	—	—	16	1	—	—	13	4
294	rbh	—	—	—	—	—	—	13	3
300	RBh	19	2	—	—	—	—	15	6
305	RBh	—	—	—	—	12	6	—	—
307	RBh	—	—	—	—	13	7	—	—
308	RBH	17	1	11	7	—	—	15	3
360	RBh	17	3	—	—	—	—	—	—
361	RBh	14	3	—	—	13	4	—	—
146	RBh	—	—	—	—	7	3	—	—
185	RBH	—	—	13	3	—	—	—	—
364	RBh	—	—	—	—	13	4	—	—
369	RBh	6	2	—	—	—	—	—	—
370	RBh	5	1	—	—	—	—	—	—
Totals	...	120	28	94	27	89	33	101	29
		4.3	1	3.5	1	2.7	1	3.5	1

* R=Red glumes; r=white glumes.
H=Hairy glumes; h=smooth glumes.
B=Not fully bearded; b=fully bearded.
G=Red Straw; g=golden straw.

The results obtained are given in full in Table I, and they appear to show conclusively a monohybrid segregation for each pair of characters concerned. Thus each parent plant would appear to have been heterozygous in respect of one or more characters. As no artificial crossing is known to have occurred in " Hen Gymro " and since also it is not probable that mutation proceeds at the rate suggested by these results, the obvious conclusion is that these hybrids were the result of natural crossing. There, is, however, nothing to show actually when this occurred. It is probable that some were the result of natural crossing in 1919 and some the result of earlier crossing. In any case, 21 out of the 209 lots came under this category—practically 10 per cent.

In order to obtain further evidence, Experiment C 56, 1921-22, was set up. For this experiment, ten out of the above twenty-one lots were used, and in some cases each plant in the lot was represented by a row in the new experiment, while other lots were represented by the progeny of selected plants. All the results of Experiment C 56, except those obtained for line Ca 360, confirmed the conclusions reached from the original experiment.

In the case of Ca 360, segregation in the first instance was for glume colour, and in this line, this character, owing to an adverse season, was poorly developed in 1922.

Thus, leaving out Ca 360, we have 20 lots out of 209 showing segregation, or approximately 10 per cent.

Further ear separations from the original lots of " Hen Gymro " were made in 1921 Fifty-six ears were selected, and four of these gave segregation in 1922. Thus, out of a total of 265 selected ears, at least 24 were found to be heterozygous in respect of one or more of these four pairs of contrasting characters—nine per cent. as compared with four per cent. obtained by Garber and Quesenberry.[4]

B. *Lots in which the majority of the plants showed the recessive of a pair of contrasting characters.*

Of the 209 lots in Experiment C 29, nineteen were of this type. Fourteen of these lots gave a single plant each showing the dominant character of a pair in contrast with the corresponding recessive in the parent and in the sister plants, while the remaining five lots gave two such plants each.

In the entire experiment there were about 3,600 plants, so that the total of twenty-four odd plants gives a percentage of 0.67, as compared with 0.16 obtained by Garber and Quesenberry.[4]

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[4] *Loc. cit.*

The suggestion seemed to be that these plants were due to crossing in 1920. To test this, Experiment C 58, 1921-22 was set up. In this, seventeen of the twenty-four plants were represented by progeny, together with other plants from the same lines, typical for their respective lines.

Unfortunately, the season 1922 was unfavourable for the development of straw colour, so that reliable results were not obtained in the case of three out of the seventeen lots. In the remaining fourteen, quite definite segregation occurred, thus showing that these odd plants found in Experiment C 29 were again the result of natural crossing.

It is obvious that in this category, only crosses occurring in one direction would be readily detected, since in a line showing the dominant character a heterozygous plant would not be appreciably different from the homozygous plant.* Thus it can probably be assumed that the same number of crosses would occur in either direction and that only one half of them would be detected. On this assumption, the number of such odd plants in the experiment would be 18, or about 1.3 per cent.

It will at once be noticed that the results obtained under categories A and B, while they agree in showing that natural crossing had occurred, differ widely in the extent of such natural crossing indicated. The following considerations probably have a bearing on this point:—

1. The original selection of ears was not strictly at random, and it is possible that owing to this fact, a greater number of ears from heterozygous plants were selected than would be given by random sampling. This would mean that the nine per cent. indicated under category A is too high.
2. Hilgendorf[2] has shown that extreme cold may have an effect on natural crossing, while Pridham[7] considers that dry and hot weather at flowering time favour the phenomenon. At Aberystwyth, the season 1920 was extremely cold and wet and it is therefore possible that the 1.3 per cent. indicated by the results for this year is below normal.
3. The crosses constituting the nine per cent. recorded under Category A are not to be regarded as all having occurred within the one season 1919. With a relatively high average annual crossing there must be a cumulative effect up to the

* One such case was accidentally discovered. In Experiment C58, one of the lots expected to segregate for straw colour actually segregated for glume colour.

2 *Loc. cit.*

7 Pridham, J. T. "Natural Crossing—a Danger in Growing Seed Wheat." *Agr. Gaz. of New South Wales*, 33 (1922), pp. 849—850.

point where this is counter-balanced by the average annual segregation. With a fixed amount of annual crossing, this *point would be a constant, but in the case of wheat where probably the amount of crossing that occurs in any one season depends upon the season itself an absolute constant is not* reached. At the same time it would be interesting to determine at what point, with an annual crossing of 1.3 per cent., would a constant be reached; or, contrariwise, what amount of annual crossing would result in a constant heterozygosity of nine per cent.

It must be borne in mind, however, that these percentages do not necessarily indicate the actual amount of natural crossing that occurs in " Hen Gymro." This could only be determined by means of specially designed experiments which would be carried through several seasons. At the same time, they do indicate that the amount of crossing that does take place under ordinary field conditions is not negligible even under what must be considered adverse conditions.

Reverting, in conclusion, to the claim made that " Hen Gymro " excels in producing a good average crop over a number of seasons, the following points are suggested as being worthy of further investigation:—

1. Has the claim any foundation on fact.
2. If so, to what extent is this superiority due to the fact that " Hen Gymro " as usually grown consists of a mixture of types.
3. To what extent is it affected by the fact that a considerable amount of natural crossing occurs season after season.

THE VARIATION IN THE MOISTURE AND NITROGEN CONTENT OF THE POTATO DURING GROWTH AND STORAGE.

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Desiring information as to the variation taking place during growth in the moisture and nitrogen content of the potato amongst other plants, and having failed to find this in any detail in the works of reference consulted, the following determinations were made with one and the same variety of potato during two seasons.

Arran Comrade, the variety examined, was grown in seasons 1922 and 1923 under field conditions at the College Farm, Nantcellan, the seed being obtained from Scotland. The soil, on which the crops were grown, is well supplied with phosphates, potash and lime, but owing to its light nature, the open character of the subsoil, and its continued cultivation, is low in organic matter. The crop received a dressing of 15 tons of farmyard manure, 1 cwt. of sulphate of ammonia, and 3 cwts. of superphosphate per acre, the general management and manurial treatment being the same in both years.

Season 1922, for the growing of potatoes, was much more favourable than 1923, the crop grown at Nantcellan in the first season being estimated as well over two tons per acre heavier than that harvested in 1923. The cold weather in the late spring of 1923 militated against an early growth, and the wet weather experienced in the autumn resulted in the crop being lifted and stored in rather a dirty condition.

The potatoes in both seasons were planted in April and lifted in October, the first sample for examination being taken in June, the tubers at the time being the size of marbles. Subsequent to this, monthly samples were taken until the crop was lifted. In the latter part of October, a portion of the crop for further examination was carefully stored in a pit, and the first of the samples during storage was withdrawn in December.

The method of sampling and preparation for analysis was that adopted by the Sub-Committee appointed to inquire into the composition of potatoes grown in the United Kingdom.[1]

Table 1 and 2 give for the two seasons the percentage of moisture, dry matter, total and protein nitrogen found at the different dates of sampling, together with the calculated total and protein nitrogen in the dry matter of the potatoes.

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1 Report on the Composition of Potatoes in the United Kingdom. April. 1919. Harrison and Sons. Ltd., St. Martin's Lane, London, W.C. 2.

TABLE I.

1922—1923.

Date of Sampling.	IN POTATO.				IN DRY MATTER.	
	Per cent. Moisture.	Per cent. Dry Matter.	Per cent. Total Nitrogen.	Per cent. Protein Nitrogen.	Per cent. Total Nitrogen.	Protein Nitrogen.
Seed Potato.	78.34	21.66	0.361	0.209	1.67	0.96
23 : 6 : 22.	82.65	17.35	0.258	0.118	1.49	0.68
23 : 7 : 22.	82.44	17.56	0.212	0.107	1.21	0.60
23 : 8 : 22.	80.00	20.00	0.210	0.107	1.06	0.53
23 : 9 : 22.	77.91	22.09	0.287	0.152	1.30	0.68
20 :10 : 22.	77.84	22.16	0.299	0.172	1.35	0.77
14 :12 : 22.	77.60	22.40	0.305	0.177	1.36	0.79
14 : 1 : 23.	77.63	22.37	0.312	0.179	1.39	0.80
14 : 2 : 23.	77.47	22.53	0.315	0.180	1.39	0.79
14 : 3 : 23.	77.52	22.48	0.308	0.177	1.37	0.78
14 : 4 : 23.	77.33	22.67	0.316	0.181	1.39	0.79

TABLE II.

1923—1924.

Date of Sampling.	IN POTATO.				IN DRY MATTER.	
	Per cent. Moisture.	Per cent. Dry Matter.	Per cent. Total Nitrogen.	Per cent. Protein Nitrogen.	Total Nitrogen.	Protein Nitrogen.
Seed Potato.	77.85	22.15	0.398	0.238	1.80	1.07
26 : 6 : 23.	83.17	16.83	0.218	0.095	1.30	0.56
26 : 7 : 23.	82.91	17.09	0.189	0.082	1.11	0.47
26 : 8 : 23.	81.64	18.36	0.222	0.101	1.21	0.55
26 : 9 : 23.	80.73	19.27	0.231	0.115	1.20	0.59
26 : 10 : 23.	79.16	20.84	0.268	0.148	1.29	0.71
19 : 12 : 23.	78.72	21.28	0.283	0.155	1.33	0.72
19 : 1 : 24.	78.61	21.39	0.290	0.160	1.36	0.74
19 : 2 : 24.	78.55	21.45	0.296	0.163	1.38	0.76
19 : 3 : 24.	78.36	21.64	0.292	0.161	1.35	0.74
19 : 4 : 24.	78.12	21.88	0.297	0.164	1.36	0.74

Reference to these Tables shows that the principal changes taking place as growth proceeds are a gradual decrease in the moisture content with a corresponding increase in the dry matter of the potatoes. In a similar manner the percentage of total nitrogen, with the exception of the June sample, shows a steady increase. With regard to the percentage of total nitrogen in the first (June) sample, although at this date it is comparatively high, the ratio of protein to total nitrogen is lower than at any other time. As the season advances, however, this ratio gradually increases until at the time of harvesting it forms from 55 to 58 per cent. of the total.

During storage there appears to be but very slight variation, there is a small increase in the percentage of dry matter and total nitrogen, but the ratio of protein to total nitrogen, during this period remains fairly constant.

A comparison of Table 1 and 2 is of interest as showing the influence of season. In 1922 the percentage of dry matter, total nitrogen and the percentage of protein nitrogen in the total, is consistently higher than in 1923, indicating an earlier growth and a higher state of maturity in the first season than in the second. Judged by these results, the 1922 crop, in addition to being heavier in yield, is superior also in feeding quality.

As only one variety has been examined and this only for two seasons, it is obvious that where so many factors are involved, it is necessary to have records for a considerable number of years before any definite conclusions can be arrived at.

At the time of sampling the potatoes, a sample of the haulms (tops) was also taken, and the determination made in the case of the potatoes repeated with the haulms.

Table 3 gives the percentage of moisture, dry matter, total and protein nitrogen found in the dry matter, together with the calculated total and protein nitrogen in the haulms.

TABLE III.

Season 1922.

Date of Sampling.	HAULMS.				HAULMS DRY MATTER.	
	Per cent. Moisture.	Per cent. Dry Matter.	Per cent. Total Nitrogen.	Per cent. Protein Nitrogen.	Per cent. Total Nitrogen.	Per cent. Protein Nitrogen.
23 : 6 : 22.	87.00	13.00	0.513	0.307	3.95	2.36
23 : 7 : 22.	89.15	10.85	0.320	0.192	2.95	1.77
23 : 8 : 22.	83.78	16.22	0.277	0.210	1.70	1.29
23 : 9 : 22.	72.72	27.28	0.368	0.294	1.34	1.07
23 : 10 : 22.	22.19	77.81	1.149	0.970	1.47	1.24

Season 1923.

Date of Sampling.	HAULMS.				HAULMS DRY MATTER.	
	Per cent. Moisture.	Per cent. Dry Matter.	Per cent. Total Nitrogen.	Per cent. Protein Nitrogen.	Per cent. Total Nitrogen.	Per cent. Protein Nitrogen.
26 : 6 : 23.	88.61	11.39	0.529	0.290	4.65	2.54
26 : 7 : 23.	90.84	9.16	0.263	0.131	2.88	1.43
26 : 8 : 23.	84.66	15.34	0.185	0.138	1.20	0.89
26 : 9 : 23.	76.11	23.89	0.328	0.255	1.37	1.05
26 : 10 : 23.	30.32	69.68	1.014	0.812	1.45	1.16

The results on the whole show a fair agreement in both seasons, the percentage of moisture, however, in the haulms in 1923 is throughout higher than in 1922. This is probably due, as was the case with the tuber, to the seasonal effect already referred to. On consulting the notes taken at the time of sampling in October, it is found that in 1922 they are described as dry, stick-like and of a dark brown colour, whereas, in 1923 there was still some green colour remaining.

The high nitrogenous contents of the haulms naturally raises the question of their suitability as green fodder for stock. On the continent, potato haulms are quite commonly used as a food stuff, and when made into hay or silage are looked upon as equal in value to meadow hay.

In our own country it is quite a common custom, in certain districts, to utilise the haulms during June and July, mixed with different dairy by products as food for pigs. Unfortunately, the haulms and to a smaller extent the whole plant, especially green potatoes that have been exposed to the light and sprouted potatoes, contain a nitrogenous constituent named solanine. This, when present in sufficient quantity renders them poisonous to stock and the feeding of these is consequently attended with grave risks, numerous cases being recorded where fatal results have followed.

EXPERIMENTS ON THE GROWING OF EARLY POTATOES.

By W. E. D. Jones, M.A., Dip. Agric. (*Cantab.*),

Agricultural Organiser for Pembrokeshire.

A number of experiments have been carried out in Pembrokeshire during the last three years with the object of ascertaining the financial possibilities of early potato growing. The prospects seemed good, for the county has a very long coast line, a very mild climate, and the southern portion along the coast is very free from frosts. Exceptionally early crops have been grown for many years in small cottage gardens, but there is no record of any attempt to develop the crop on a field scale. It was therefore decided to put down two experiments of about an acre each in the 1922 season. The centres selected were not exceptionally favoured spots. As a matter of fact the aspect in the trials was North and West respectively, so that the fields were not the earliest that could be found. They were fairly typical of the conditions obtaining along the south coast.

Experiment I.

Mr. A. W. Gutch, Land Agent, undertook an acre trial with Scotch seed of "Epicure" at the Home Farm, Angle, by the kind permission of Mrs. Mirehouse. The field selected had a northern aspect and contained a light loam on the Old Red Sandstone formation. Mr. Gutch estimated that there were only three inches of soil over the solid rock in a large portion of the acre and where the soil was deepest there were six inches. The seed was boxed on January 16th, 1922. As the boxes were estimated to last five years at least, one-fifth of the bill for boxes and carriage has been included in the balance sheet. As the financial statement indicates, the cultivations were carried out by means of horse labour.

The drills were 26 inches apart and the sets were planted at 11 to 12 inches apart. After planting, the drills were split back over the "seed" with the ridging plough in the usual way. This is mentioned on account of the fact that a number of farmers who were interested in the experiment asked for information on this point. They had expected that sprouted "seed" might need covering by hand labour.

The field had been given farmyard manure in the autumn at the rate of fifteen loads per acre, *i.e.*, about twelve tons. In addition, the following mixture of artificials was applied in the drills at the time of planting:—

3	Cwts.	Superphosphate,
2	,,	Sulphate of Ammonia,
1	,,	Steam Bone Flour,
1	,,	Sulphate of Potash.

These artificial manures were selected in order to supply the crop with all necessary manures in a soluble and readily available condition so that the crop might develop rapidly for an early market.

Although the Angle district is usually very free from frosts there was an exceptionally severe spell of cold weather at the end of March and at the beginning of April, which checked growth considerably. It might be of interest to report that local farmers estimated that had it not been for this severe spell of cold weather, the crop would have been lifted on June 1st and not on June 12th.

Although careful records were kept of all the man and horse labour employed in working the experiment, the cost of each cultivation operation is, after all, an estimate based on the amount of labour. To illustrate this difficulty I need only mention one point, viz., that some of the operations involved fractions of days. We were very greatly helped in this work by Mr. Ashby, of the School of Rural Economics, Oxford, who examined the records on the spot. Where there was any difference in the estimates of the cost of the cultiva-

tions, the figure shown in the balance sheet is the highest. This is done in order to avoid any inflated or unreal profit. The cost of the Farmyard Manure is omitted as an offset to the residual value of the total manuring.

Potato Trial, Angle, 1922.

	£	s.	d.	£	s.	d.
Carted out F.Y.M. 15 loads (about 12 tons) at 3s. 6d.				2	12	6
Spreading F.Y.M., one man one day				0	6	0
Autumn ploughing (estimated ¾ acre per day as this was done before experiment was arranged)				1	10	0
One Ton Scotch "Seed" "Epicure", £12 10s. and carriage £4 8s. 2d.				16	18	2
Boxing Seed, one man one day				0	6	0
Spring Ploughing, one man and two horses, one acre per day ...				0	18	0
Chisel Harrowing, three horses and man four to five acre per day ...				0	6	0
Ploughing, two horses and one man, one day				0	18	0
Planting, five men, half day				0	15	0
Opening ridges, two horses and one man, two acres per day ...				0	9	0
Artificial manures—	£	s.	d.			
1 Cwt. Bone Meal	0	11	0			
2 „ Sulphate of Ammonia	2	0	0			
3 „ Superphosphate	0	18	0			
1 „ Sulphate of Potash	0	17	6			
Carriage and carting	0	13	5			
				4	19	11
Mixing and sowing artificials, one man half day				0	3	0
Closing ridges, two horses and one man, two acres per day ...				0	9	0
Horse hoeing, one horse and one man, half day				0	6	0
„ „ „ „ „				0	6	0
Weeding drills by hand, 3½ man days				1	1	0
Earthing up, one horse and one man, half day				0	6	0
Lifting by hand, sacking and weighing 18 man days ...				5	8	0
Cost of Sprouting Boxes (one-fifth of bill)				1	0	9
Rent, one year, one acre				1	10	0
Rates ditto				0	10	9
				£40	19	1
				£	s.	d.
By five tons twelve cwts. Potatoes Sold				120	12	10
Balance, net profit per acre				£79	13	9

The crop was lifted in sections from June 12th to July 4th. The first lot to be raised realised £40 per ton, and the last realised £18 per ton. The average price of the crop was approximately £21 12s. per ton. On July 11th the land was sown with swedes which were singled on August 4th.

Experiment II.

Mr. J. Belton, of Gellyswick, near Milford Haven, grew three-quarters of an acre of Epicure, under practically the same conditions

as obtained at Angle. The only points in which this trial differed from the previous one are indicated in the following notes:—

Aspect West.

The "seed" was not boxed.

A distance of 1 foot separated the sets in the drills, which which were 2 feet 6 inches apart.

Size of plot: 200 yards long by 18 yards wide.

Potato Trial, Milford, 1922.

	£	s.	d.
Carting, loading and spreading F.Y.M.	3	0	0
Autumn ploughing, 1 man and 2 horses, 1 day	0	18	0
"Seed," £9 and carriage	12	6	1
Spring ploughing, 1 man and 2 horses, ¾ day	0	13	6
Harrowing and rolling, 1 hour each	0	4	6
Opening ridges, ½ day	0	4	6
Planting (March 15th), 2 men, 1 day	0	12	0
Artificial manures, £4 6s. 6d. and 5s. carriage	4	11	6
Closing ridges	0	4	6
Hoeing	0	4	6
Weeding, 1 man, ½ day—very clean land	0	3	0
Earthing up	0	4	6
Lifting 20 drills [1 man does 3 drills per day]	2	2	0
Rent	0	18	9
Rates, 4s. 4d. in £	0	4	1
	£26	11	5
By 4 tons, 1½ cwts potatoes at £20 per ton	81	10	0
Balance, net profit on ¾ acre	54	18	6
Net profit per acre	£73	4	8

White turnips were planted in the third week of July.

1923 Results.

A number of local farmers who saw the 1922 experiment became interested and decided to repeat the test in detail for themselves in the following season. Four of these arranged at the outset to supply the writer with a complete record of their observations. The season in 1923 was very unfavourable for growing early crops on account of the exceptionally cold period in the month of May, together with the abnormally low prices which were offered for early potatoes. In spite, however, of these serious disadvantages, one farmer made a net profit of £27 12s. 6½d. per acre, while another followed closely with a net profit of £24 1s. 2d. per acre. The average of the four experiments showed a net profit of £16 4s. 11¾d. per acre. The profits were higher than was at first expected and in spite of the disappointment felt by the experimenters in the early part of the

season, each farmer is continuing the acre trial again this season. One has extended the experiment to two acres and the total number of those who are giving the crop a trial is increasing rapidly. After the very severe test in 1923 the results indicate that farming would be more remunerative in South Pembrokeshire if efforts were made by local farmers to increase the acreage under this crop.

The prospects for the current season (1924) are better than they were at the corresponding period last year, for although we have again had a very cold, backward spring, the prices have improved considerably. One of the experimenters has sold his crop at £28 per ton.

There is room for considerable development along the Coast and some of the farmers are already suggesting that steps should be taken to form an Association of Early Potato Growers. Local markets were gutted last year with locally grown earlies, as no arrangements had been made to get into touch with merchants outside the county. The conditions are favourable for the cultivation of this crop along the entire coast regions of the county, and our coast is a very long one. Therefore, if disappointment is to be avoided the growers must co-operate at an early date, in order to be able to supply markets in the large industrial towns of South Wales. The crop can be grown in good time to obtain a fair share of the orders in South Wales. We can depend on the soil, climate and freedom from frost, but the human factor has yet to be tested. "Every prospect pleases," but some small group of farmers, in order to develop the industry, will have to "pull the chestnuts out of the fire."

WINTER KEEP.

By R. D. Williams, B.Sc.,

Welsh Plant Breeding Station, Aberystwyth.

During the winter and early spring, the problem of finding sufficient keep for sheep is often a source of considerable anxiety to the flockmaster. As a rule he has to depend very largely on his first ley to tide him over the critical months of February and March. As the area under "seeds" is generally inadequate for this purpose, the first year leys are often irreparably damaged as a result of overgrazing during this period.

There are several well recognised methods of increasing the supply of winter grazing, which entail only slight modifications of the

current farm practices. Most farmers are aware that temporary pastures during the first two years are more productive, particularly during the winter months, than old leys, which on upland farms consist almost exclusively of bent. The most economical method of converting these unproductive fields into good pastures is to "rape pasture" them as advocated by Stapledon and others.*

In the hilly districts of Wales, the stubbles are seldom ploughed before early March, on account of the heavy rainfall during the autumn and winter months. A very considerable area is thus allowed to remain idle during five months of the year. These unproductive acres could be made to contribute a very appreciable amount of winter keep by sowing a suitable grass or clover under the corn in the spring.

Again, the practice, which has been adopted with good results in certain parts of the country of sowing certain quick-growing winter-hardy crops during the summer for the sole purpose of supplying sufficient succulent feed for the ewes and lambs in the spring, could be adopted with advantage on most hill farms.

In order to compare the relative value of a large number of species of forage plants for stubble grazing and spring keep, a series of experiments were conducted at the Plant Breeding Station, Aberystwyth, during the years 1920—24.

E.9. In the spring of 1920, some thirty-six different species of indigenous and exotic grasses and legumes were sown—pure and in mixtures—under oats, with the object of comparing the amount of keep they supplied during the following autumn. The experiment was conducted in Penglais field on light shallow soil. The oats were sown on 22nd April, and the seeds were sown broadcast on rod plots on the following day. Owing to wet weather, the oats were not harvested until the third week in September. The plots were grazed by sheep during the latter part of October and were then ploughed up about the middle of November.

Most of the exotic species, namely: Johnson Grass; Dallas Grass; Canary Grass; Teff Grass; Teosinte; Slender Wheat Grass; Carpet Grass; Natal Red Top; Rhodes Grass; Ragi millet and Japan Clover either failed to germinate or to become established. Cluster Clover and Strawberry Clover also germinated poorly, and the few plants that did survive were too small to afford any grazing. Cocksfoot, Tall Oat Grass and Rough Stalked Meadow Grass gave fairly dense swards, but their growth came to a standstill too early in the autumn.

* See Stapledon, R. G. "Putting Land Down to Grass." Address delivered to the Taunton Show of the Bath and West and Southern Counties Society, 1924.

The annual legumes, namely, Crimson Clover; the various vetches, *Vicia sativa, V. villosa, V. fulgens, V. atropurpurea, V. angustifolia* and *V. narbonnensis* and *Trifolium alexandrinum* proved totally unsuitable, as they produced practically no secondary growth. The different melilots, *M. alba, M. officinalis, M. leucantha* and *M. indica;* and Sulla (*Hedysarum coronarium*) gave equally unsatisfactory results.

Both Field Brome Grass (*Bromus arvensis*) and Westernwolth Rye Grass made very rapid recovery during October, but the growth, though tall, was too thin to afford much keep.

Of all the different species included in this experiment, Subterranean Clover and Chilian, Italian and English Broad Red Clover with Late Flowering Red Clover were the only crops that produced any appreciable amount of keep during the autumn.

E.23. A similar experiment was again carried out in 1922, with the different species of grasses and clovers shown in Table I. The seeds were sown under Record oats in the first week of April, on 1/200th acre plots replicated three times. The oats were cut by binder on 8th September, but portions of each plot were cut by scythe and tied into separate sheaves in order to ascertain if the rate at which they dried was in any way affected by the green produce they contained.

Tall Oat Grass, Italian Rye Grass, "Perennital," Red Clover, Alsike and *Lotus angustissimus* were the only species that produced tall growth in the corn, of these, Red Clover, on account of the much more succulent nature of its stems, proved by far the most difficult to dry.

The plots were grazed by sheep during the latter half of December and again in March. On the 13th March, before the sheep were turned on, a few of the best plots were cut by means of a lawn mower. The results thus obtained, together with the relative amount of keep as estimated by the eye supplied by the different species during September and November are shown in Table I.

During September and early October the greatest amount of keep was produced by English Broad Red Clover, while the other two Red Clovers, Italian Rye Grass, *Lotus angustissimus* and Tall Oat Grass also produced a considerable amount of keep during this period, but by November all the species were easily surpassed by Italian Rye Grass, which maintained this superiority throughout the winter months until the middle of March. It was estimated that it gave about twice as much grazing as any other species from September to March.

TABLE I.

Showing the relative amount of autumn keep and the actual amount of spring keep supplied by various grasses and legumes grown under spring oats for stubble grazing.

	Rates of seeding. lbs. per acre.	1923 Relative Keep. Sept.	1923 Relative Keep. Nov.	1924 Relative Keep. March.	1924 lb per. acre green fodder. March.
Italian Rye Grass ...	15	100	100	100	2880
	7½	66	53	71	1670
Perenital ...	15	57	45	53	1520
Tall Oat Grass ...	30	85	60	25	—
	15	30	20	15	—
Italian Rye Grass and Broad Red Clover (Mixture) ...	5, 2½	91	53	42	1210
Broad Red Clover ...	10	114	47	41	1200
Chilian Red Clover ...	10	92	37	18	520
English Late Flowering Red ...	10	106	32	18	—
Lotus hispidus ...	8	43	40	11	—
L.angustissimus ...	8	100	63	5	—
L.corniculatus ...	10	34	7	11	—
Alsike ...	8	46	5	5	—
Subterranean Clover ...	20	37	20	5	—
Sulla ...	15	17	10	—	—

Both Italian Rye Grass and Tall Oat Grass were sown at two rates of seeding. The figures given in Table I for the two rates clearly demonstrate in the case of Italian Rye Grass, the seeds of which are fairly cheap, that the additional grazing afforded by the heavier seeding has more than compensated for the extra price paid for the seed.

The difference in the amount of growth supplied by the portions of the plots cut by binder and by scythe was so striking as to be worthy of mention. The portions cut by scythe were badly checked as a result of close cutting, that even as late as March, some six months later, the differences between the amount of growth on the portions cut by scythe and by binder was still very considerable.

E.42. Another experiment was conducted on Penglais field in 1923 in order to compare still further the suitability of certain species for autumn stubble grazing. The seeds were sown at two rates, of 10lb. and 5 lb. per acre, early in April, on duplicated 1/100th acre plots under Radnorshire Sprig Oats.

The average amount of keep supplied by the different species is shown in Table II.

TABLE II.

Showing the relative amount of grazing given during September, October and November, by the different species sown for stubble grazing. Percentage figures based on Italian Rye Grass=100.

Species.	*Seeding per acre.*	
	10 *lb.*	5 *lb.*
Italian Rye Grass ...	100	45
Lotus angustissimus ...	90	30
Rape ...	90*	—
Broad Red Clover ...	40	20
Canary Grass (Phalaris bulbosa)	30	—
Yellow Suckling Clover ...	25	20
Lotus hispidus ...	20	17
White Clover (Dutch) ...	20	trace
Tall Fescue ...	10	trace
Melilotus alba } .. M. alba, var. annua } ..	0	0

* Sown at 6 lbs. per acre.

All the species, with the exception of Tall Fescue and the two melilots, gave fairly satisfactory stands.

As in E.23, the best results were given by Italian Rye Grass, but *Lotus angustissimus* and Rape produced nearly as much keep as Italian Rye Grass during these three months. The amount of feed supplied by the other species was relatively very small.

B.101. Data bearing on the amount of winter growth produced by different species of grasses were obtained from another experiment sown in Brick field in May, 1922. The main object of this experiment was to determine the productivity of different nationalities of the various species of grasses in common use.

The plots were grazed fairly closely by sheep during December, and then put up for hay on the 31st of that month. On the 14th March, 1922, two strips, each 21 feet long and 20 inches wide, on each plot, were cut by means of a lawn mower. The results which represent the amount of growth produced during January, February and the first two weeks of March are summarised in Table III.

TABLE III.

Showing the average weight of green fodder produced by the different species of grasses during period—1st January to 14th March, 1923.

	No. of plots averaged.	*lbs. per acre.*	*Relative yield.*
Tall Fescue ...	3	2530	100
Italian Rye Grass ...	12	2260	89
Perennial Rye Grass ...	12	1280	50
Meadow Fescue ...	6	870	34
Cocksfoot ...	11	830	32
Golden Oat Grass ...	2	670	26
Meadow Foxtail ...	4	430	17
Timothy ...	4	240	9

It is thus seen during the winter period under review that Tall Fescue and Italian Rye Grass produced about twice as much green fodder as Perennial Rye Grass, and that the latter was greatly superior to Meadow Fescue, Cocksfoot and Golden Oat Grass, and that Meadow Foxtail produced less than one-fifth and Timothy less than one-tenth of the keep produced by Tall Fescue.

Tall Fescue and Italian Rye Grass stand in a class of their own, as regards the amount of winter growth they produce. From about November to the end of January, Italian Rye Grass is distinctly better than Tall Fescue, but the latter makes very rapid headway during February and March, and is generally superior to Italian Rye Grass during this period.

E.38. In order to carry out a quantitative test of the relative value of Italian Rye Grass and Broad Red Clover for autumn, winter and spring grazing, two $1\frac{1}{8}$ acre plots were sown on the 4th May, 1923, respectively with 8 lb. per acre of Suffolk Broad Red Clover, and 11 lb. per acre of Italian Rye Grass. Both plots gave excellent stands. The plots were grazed intermittently by sheep from the 14th August to the end of March, the number of sheep being regulated according to the amount of keep available on the plots. During the first three months (and again during January and February in the case of the Italian Rye Grass plot) the sheep were weighed about every four weeks. The carrying capacity of the plots and the increase in the live weight of the sheep were taken as the criterion for comparing the relative value of the two species.

TABLE IV.

Showing the number of sheep—expressed as sheep days—carried by 1¼ acre plots of Red Clover and Italian Rye Grass from the middle of August to the end of March.

Month.		Number of Sheep Days.	
		Italian Rye Grass.	*Red Clover.*
1923	August ...	125	125
	September ...	290	290
	October ...	310	310
	November ...	50	50
	December* ...	—	—
1924	January ...	25	0
	February ...	100	0
	March ...	76	0
	Total ...	976	775

* The plots were advisedly rested during December.

TABLE V.

Showing the average Live Weight Increases per sheep on pure plots of Italian Rye Grass and Red Clover.

Periods.	*No. of sheep.*	*Live Weight Increase lb. per sheep.*	
		Italian Rye Grass.	*Red Clover.*
August 14—August 24 ...	5	7.55	9.75
August 25—September 13 ...	5	5.55	6.70
September 14—October 13 ...	10	2.05	3.48
October 14—November 5 ...	10	2.20	0.80
January 26—February 20 ...	5	5.20	—

If the live weight increases given by the Clover and Italian Rye Grass plots are compared, it will be seen that up to the middle of October, when the keep on both plots was very plentiful, the Clover plot gave distinctly greater live weight increases than the Italian Rye Grass plot. About the middle of October the growth of the Red Clover to all intents and purposes came to a standstill, but the grass continued to supply quite an appreciable amount of grazing. The difference in the behaviour of the two species during this period is well reflected in the sudden very decided fall of the live weight increase given by the Red Clover as compared with Italian Rye Grass during the period 13th October to 5th November.

As shown in Table IV, the same number of sheep were kept on the two plots from August to November. Both plots supplied an abundant amount of grazing up to the middle of October, but from that period until the end of March the Red Clover plot made

practically no growth; the Italian Rye Grass plot, on the other hand, continued to supply fresh growth through the winter and early spring months and to maintain quite a number of sheep during the first three months of the year. The main results of this experiment may then be stated as follows:—During the late summer and early autumn Red Clover was quite as productive as Italian Rye Grass, and for fattening sheep the Clover was decidedly superior to the grass, but during the late autumn, winter and spring months, Italian Rye Grass supplied immeasurably more keep than the Red Clover.

E.21. Two experiments, one during 1921—22 and the other during 1922—23, were conducted with the object of comparing the winter productivity of certain grasses, clovers and a few miscellaneous crops with the various crucifers generally sown for this purpose. Both experiments were sown in drills 27 inches apart on duplicated plots about 1/40th acre in size. The crucifers were sown at approximately 6 lb. per acre in 1921 and 8 lb. in 1922, while grasses and clovers were sown at about 10 lb. per acre.

E.21. Part I. This experiment was sown in Upper Ridge Field on 29th August, 1921.

From observations made soon after germination it was evident that most of the crucifers had been sown too thinly, and that a seeding of 6 lb. per acre when sown so late as the end of August was not sufficient to give good stands.

The plots were lightly grazed by sheep during December, and again during the following April. The observations given are percentage figures, with Italian Rye Grass fixed at par.

TABLE VI.

Showing the average amount of keep supplied during November and April by different forage crops, sown in late August to supply winter grazing for sheep.

	November, 1921.	*April*, 1922.
Italian Rye Grass ...	100	100
Perennial Rye Grass ...	58	75
Tall Oat Grass ...	30	50
Cocksfoot ...	30	50
English Broad Red Clover ...	30	25
Chilian Red Clover ...	30	25
Crimson Clover ...	58	0
Buckwheat ...	100	0
Chicory ...	70	25
Hardy Green Turnip ...	140	125
Thousand Headed Kale ...	100	20
Green Marrow Stemmed Kale ...	86	20
Purple Marrow Stemmed Kale ...	86	20
Kohl Rabi ...	30	10
Hardy Scotch Kale ...	15	10
Scotch Borecole ...	15	10
Russian Kale ..	trace	0

Although the hardy green turnip was sown too thinly, it was decidedly superior in productivity to all the other crops. Of the other crucifers, the only two that produced an appreciable amount of keep, and then only during the autumn, were green and purple marrow stemmed kales. All the other crucifers made such slow growth that they may be regarded as more or less complete failures. With the exception of hardy green turnip, all the crucifers failed to recover after being grazed in December, with the result that the amount of feed which they supplied during the winter and spring months was practically negligible.

Of the grasses and clovers, Italian Rye Grass was by far the most productive. Crimson clover was sown too late to make much headway before it was winter-killed.

Buckwheat made extraordinarily rapid growth during the first two months, and had it been sown thicker it would probably have compared quite favourably with hardy green turnip during the autumn. It was very susceptible to frost and was completely killed back during the later part of November. Chicory also made fairly good growth during the early autumn; but although it was one of the most winter hardy crops included in this experiment, it remained practically at a standstill during the winter and early spring.

E.21. Part II. The 1921 experiment was repeated with slight modification in 1922. This experiment was sown on the Knoll on 1st August. Although the seeding of the crucifers was increased from 6 lb. to 8 lb. per acre, the stands, due no doubt in part to the rather poor and shallow nature of the soil on which the experiment was conducted, were too thin. These plots were not grazed until April. 1923.

On January 11th, the produce of representative eighteen foot lengths on all plots which had sufficient growth was weighed, and on the 22nd March the same portions were again cut in order to ascertain the effect of mid-winter grazing on the various species. On the same date, eighteen foot lengths which had not been previously cut and which, therefore, represented the total growth made from the time of sowing to 22nd March, were weighed. In order to determine the percentage dry matter. small representative samples were taken from each cutting and oven dried at a temperature of 90°C—98°C. The relative yields of dry matter, expressed as percentage figures based on the yields of Italian Rye Grass fixed at par, are summarized in **Table VII.**

TABLE VII.

Showing the comparative Weights of Dry Matter yielded in January and March by various forage crops sown early in August to supply winter grazing.

	January. 1st cut.	*March. 2nd cut.*	*March. 1st cut.*
Italian Rye Grass ...	100	100	100
Perennital ...	46	—	30
Tall Oat Grass ...	42	80	35
Perennial Rye Grass ...	40	78	25
Cocksfoot ...	15	69	26
Lucerne ...	11	*	—
Sulla ...	38	*	—
Red Clover ...	*	*	5
Subterranean Clover ...	*	*	—
Hardy Green Turnip ...	145	143	151
Thousand Headed Kale ...	67	57	73
Green Marrow Stemmed Kale ...	30	27	13
Hardy Scotch Kale	12	*	*

* Growth too short or too poor to cut.

As in the 1921 experiment, the hardy green turnip and Italian Rye Grass were the only species which gave consistently good results during the winter months. Of these, the former gave considerably more dry matter than the latter, despite the more watery nature of its produce. The percentage dry matter of these crops is given below:—

	Italian Rye Grass.	*Hardy Green Turnip.*
January (1st cut) ...	20.10	12.4
March (2nd cut) ...	15.03	11.6

Perhaps an even more outstanding characteristic of hardy green turnip than its high productivity was its ability to recover rapidly after being cut or grazed, a characteristic which was not shared by any of the other crucifers included in these two experiments.

As the growth of even the best crops is naturally comparatively small during the winter, not one of the species was able to occupy more than a small fraction of the space rendered available by the wide drills, and it was quite obvious that a greater amount of keep would have been produced if the seeds had been either broadcasted or sown in narrow drills six to nine inches apart.

It was evident from the observations made on the palatability of the different species when they were grazed during April that the sheep showed a decided preference for Red Clover and Subterranean

to all other species, when the clover plots were exhausted, the sheep next turned their attention to "Perennital" and green marrow stemmed kale, and from these to Italian Rye Grass and hardy green turnip, then to Tall Oat Grass, Perennial Rye Grass and Cocksfoot, and lastly to thousand headed kale. The Italian Rye Grass was grazed fairly closely, but, on the other hand, only the leaves and the tops of the stems of the hardy green turnip were eaten, the woody portions of the stems, which constituted a high proportion of the produce, were left untouched, therefore only weights of the edible portions should be taken into consideration when drawing a comparison between the two crops.*

Summary.

The results of these experiments clearly indicate that Italian Rye Grass was outstandingly superior to all the other species tried for stubble grazing. The rapidity with which it recovers after the corn had been harvested and when grazed, its ability to continue active growth late into the autumn and winter, and to commence growth again early in the spring combine to make it the stubble crop *par excellence.* The fact that its seeds are cheap and that it is not exacting as regards soil conditions are additional advantages in its favour.

The value of Italian Rye Grass for winter grazing was emphasised by Rodwell† as early as 1841, but it was not until quite recently that any attempt was made to put this knowledge to practical use. During the last few years Italian Rye Grass has been sown under corn for the express purpose of supplying winter keep at the farm of the University College of North Wales at Bangor and at other places, with very satisfactory results.

Red Clover, particularly English Broad Red, gave quite good results up to about the middle of October. It would probably have supplied much more keep had the corn been harvested earlier. But in spite of its high nutritive value, the price of the seeds and the short growth period militate against its extended use merely for the purpose of providing winter keep.

Lotus angustissimus also produced quite a fair amount of keep during the early autumn, but, as in the case of Red Clover, it can

* The comparisons given above are, of course, not to be taken as truly representative of the behaviour of the Kales and other Crucifers, as in both years the sowing dates were unavoidably too late for these crops.

† See Rodwell, J. "On the Culture and Usefulness of Italian Rye Grass." *Jour. Roy. Agr. Soc.*, Vol. II, 1841, and "On Italian Rye Grass," *ibid*, Vol. V, 1845.

not be profitably used for stubble grazing, on account of the short period of growth during the autumn.

As rape was only included in one experiment, no definite conclusions can yet be drawn as to its suitability for stubble grazing, but the results of these experiments were so favourable as to justify further trial with this crop.

None of the other species included in the experiments under review proved suitable for stubble grazing. Even Tall Fescue, which is capable of giving excellent growth during early spring is hardly suitable, owing to the high price of its seeds and their low rate of establishment.

MODERN TENDENCIES IN SOIL RESEARCH.

By G. W. Robinson, M.A.,

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The scientific study of the soil has undergone considerable development during the past quarter century both at home and in foreign countries. So great is the number of new papers appearing each year that it is becoming increasingly difficult to do more than keep in touch with the main lines of advance. It might reasonably be expected that this great volume of work should have made its impression on agricultural practice, for the majority of workers on soils are connected with institutions whose aim is professedly to render service to cultivators of land. It must, however, be admitted that, after making all allowances for the conservatism of the farming class, no very signal improvements in practice have been effected as the direct and obvious result of the recent discoveries of soil scientists.

The writer makes this admission in no spirit of pessimism. But it is well to realise the difficulties of the problems with which the soil worker has to deal, in order to avoid a repetition of the disillusionment consequent on the failure of agricultural chemistry to fulfil the promises made for it a century ago.

The constitution of the soil and the relationship between soil and plant, which seemed so simple to the contemporaries of Liebig have now proved to be of amazing complexity. The scientific work on soils during the past generation has opened up new provinces of knowledge which have as yet only been partially explored. We must attribute to our imperfect knowledge the comparatively small effect

which soil science has exerted on practical affairs since the classical discoveries of Lawes and Gilbert.

These unknown provinces must be explored. The future pressure of population on the means of subsistence casts its shadow on the present and makes it imperative that the problems grouped around the growth of crops shall be studied and solved. And although progress has apparently been slow, when we compare our present view of the nature of the soil and its relation to plant growth with that of the preceding generation, we must realise that solid advances have been made and we may venture to expect that they will have their effect on practical agriculture at home and, what is perhaps of more importance, on the agricultural development of the Empire. The purpose of the present article is to survey briefly some of the principal provinces in which advances are being made in our knowledge of the soil and its related problems.

Soil Origins and Classification.

The study of the origin and natural occurrence of soils may seem a somewhat academic aspect of the subject, although for that matter the soil is as worthy of study from a purely philosophical standpoint as many of the subjects dealt with in the so-called pure sciences. Apart from this, however, an understanding of soil origins is essential for the important task of soil classification. There is, perhaps, no natural material for which so many systems of classification have been proposed. But whilst the principles of geological classification have been so well elucidated that geological maps are constructed on the same basis in every country, in the case of soils no generally adopted system of soil mapping has, up to the present, been evolved. It is urgently desirable, particularly in newly settled countries, to be able to characterise the properties of soils by means of maps in the same way that rocks are characterised by geological maps. This demands the study of soil origins and metamorphoses from a broad viewpoint, for principles of classification evolved from experience in one area are of limited application outside that area. The labours of Hilgard in America, of Ramann in Germany, of Murgoci in Roumania, and of Docuchaiev, Glinka and others in Russia have directed attention to the fundamental importance of climatic and situational factors in determining soil characteristics. These factors must form the basis of any universal system of soil classification just as stratigraphy forms the basis of geological mapping. A committee of European and American soil workers of which the present writer is a member, is at present considering

the question of soil mapping and has taken in hand the preparation of a preliminary soil map of Europe.

Soil Fertility.

Soil fertility is a problem which presents a great variety of aspects. With it are involved the problems of the growth and nutrition of plants, now being studied from different aspects by botanists, chemists, and soil workers. The plant physiologists attempt to elucidate the mode of growth of plants and the factors which control this growth. The soil worker attempts to discover how these factors operate under ordinary conditions of growth in soils.

At present there is a reaction from the older chemical view of soil fertility, and the present tendency is to emphasise the importance of physical properties in determining the potentialities of any given soil, The modern study of soils lies as much in the province of the physicist as of the chemist. Perhaps the most important properties of the soil are those connected with the supply of water to plants, and much attention is being given to the study of the moisture relationships of soils. In a region of generally uniform climate, differences in moisture conditions are largely responsible for the adaptation of crops to particular soils and the occurrence in one district of permanent grass and in another of uncultivated waste. The mode of supply of water to crops is also a principal factor in the adaptation of soil for forest growth.. It must also be remembered that a study of the water economy of soils is of the first importance for irrigated cultivation, to which we must look increasingly in the future to contribute to the world's food supply. It is not surprising, therefore, that some of the most important and promising work in soils at the present day deals with soil moisture, and one may expect considerable advances when the principles underlying its control are elucidated and applied to soil management.

Soil Microbiology.

Whilst the purely chemical view of soil fertility has been replaced by broader conceptions, it is still recognised that one of the most important factors in actual practice is the supply of available nitrogen to plants. This supply is, in the absence of artificial manuring, governed by the activity of the organisms concerned with the nitrogen cycle in the soil. Bacteriology is one of the youngest of the sciences, but it has found some of its most striking applications in soil science. The Rothamsted workers are mainly responsible for the impetus which has been given in recent years to the

study of soil microbiology. It is not to much to hope that the work of the Rothamsted school in England and of the New Jersey school in America may lead to developments which will make possible the utilisation of the immense nitrogen reserves of soils and the fuller exploitation of the activities of nitrogen fixing organisms.

Soil Constitution.

The physical and chemical properties of soils are connected with the fundamental question of soil constitution. The past few years have been rich in advances in our knowledge as to the nature of the constitution of the soil. Briefly, we may regard soil as consisting of a framework or skeleton of more or less decomposed minerals with which is associated organic and inorganic colloidal matter resulting from the bacterial decomposition of plant residues and from the chemical weathering of minerals. This colloidal matter occurs as a film on the surface of the more or less unaltered mineral grains, and is of the utmost importance in determining the properties of soils. Its presence is responsible for the difference between soils and mere finely divided rock material. By its action in facilitating the association of finer particles into larger compound particles or crumbs, the existence of a "tilth" is rendered possible. By reason of the large water holding capacity of colloidal material, soils are able to retain moisture for the use of plants during the intervals between rains. The colloidal material comprises the most active chemical constituents of soils and is also the medium in which the complicated micro-organic flora of the soil fulfils its activities. Recognising that the colloidal material of the soil is mainly responsible for its physical and chemical properties, a large volume of work is being directed to the study of soils from the standpoint of the principles of colloidal chemistry and physics.

One of the principal problems in this connection is the search for some method by which the amount of colloidal material or, what amounts to the same thing, the degree of colloidality of the soil can be determined. It is known that clay soils and peats are highly colloidal and that sandy soils show colloidal properties to a small degree, but some method is needed by which this difference can be expressed quantitatively. One direction in whch this problem has been attacked is by mechanical analysis. During the past few years much attention has been given to this subject and considerable improvements in technique have been effected.

Soil Analysis.

The constitution and the physical properties of soils are being studied with a view to correlating these properties with the known

characteristics of soils. The new knowledge which is being acquired implies a revolution in methods of soil analysis. Much of the failure in the past has been due to the use of methods of analysis which gave imperfect information as to the fundamental properties of soils. One of the principal objects before the soil worker is to devise methods of soil examination which shall furnish quantitative data as to those properites of the soil which are of fundamental importance. When such methods are devised it will be possible to correlate laboratory data with the behaviour of soils in the field. This will render possible the more certain use of soil analysis as a guide to the management of soils.

Probably one of the first directions in which this may be accomplished is in the matter of soil acidity and its remedy by the application of lime or calcium carbonate. This problem, which appeared so simple a generation ago, has proved on closer examination to be of considerable complexity, and the chemist has frequently been in doubt as to the proper recommendation to make. A large amount of research has been devoted to elucidating the nature of soil acidity and the action of lime and calcium salts on soils. Although there are many points which still remain to be cleared up, the general nature of the problem is now fairly well understood on the chemical side and the principal task remaining is to correlate with field results.

Soil science may be expected to be of service in influencing the utilisation of land in newly settled countries and even of uncultivated land in older countries. The importance of the subject should not be judged merely by the extent of cultivated land in Britain. As our population grows, the full development of the agricultural potentialities of the Empire will become of increasing importance. A right understanding of the mechanism of the soil and its relation to plant growth will enable this development to proceed along lines which will secure maximum production of food and the other commodities obtained from the soil. But the complexity of the problems of the soil must be realised. It is for this reason that much of the research which is being carried out at present seems rather remote from practical affairs. The elucidation of the fundamental properties of soils must, however, precede the successful application of science to practice. It is permissible to hope that during the next decade the advances which have been made in the laboratory will make their influence felt in the field and rehabilitate the science of Boussingault, Lawes and Gilbert.

THE PROBLEM OF SOIL ACIDITY IN NORTH WALES.

By Rice Williams, M.Sc.,
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Liming for the purpose of increasing crop production is an ancient practice, and at one time had a wide application in Wales. To-day it is generally omitted from our routine soil operations. The reasons for this are partly economic—high cost of materials and labour, and partly on account of the profitable returns from the use of artificial fertilisers. There is also a widespread belief amongst farmers that there is sufficient lime present in basic slag and other phosphates to satisfy the requirements of the soil in this respect. The typical soils of North Wales are derived from rocks devoid of calcium carbonate, so that these soils do not possess any natural reserves of this constituent. Soils actually derived from limestones occupy a comparatively small area, and are often found to contain little or no calcium carbonate, a condition caused by the leaching consequent on the high rainfall of the area. The small amounts of calcium carbonate found in some of our soils are probably the residues from heavy dressings applied in the past and which, up to the present, have not been completely leached out. In general, no marked falling off in productivity seems to have followed the removal of this constituent. In fact, many of the most fertile soils in North Wales contain no calcium carbonate. Also, liming experiments on soils devoid of calcium carbonate, and giving certain tests indicating the need for lime, showed no result in some cases, whilst in others an increase in crop was obtained.

The absence of calcium carbonate is not, therefore, a reliable indication of the need for liming. Such being the case, is it possible for the soil investigator, by means of any special tests, to reach a definite conclusion on the point? In the following pages the writer will attempt to sketch in outline what appear to be the main aspects of the problem.

Many tests and methods have been recommended for the determination of the lime requirement of soils. The reaction of the soil is the principal character used in devising and elaborating such tests, and soils showing an acid reaction are commonly supposed to require lime in order to correct this acidity.

The litmus paper test is the simplest and oldest. By it, most North Wales soils are acid, *i.e.*, they turn blue litmus red. The

newer methods, such as the Comber thiocyanate test and the Hutchinson and MacLennan lime requirement method, also show positive lime requirements for nearly all these soils. It is claimed that the Hutchinson and MacLennan and certain other methods, can give a quantitative indication of the lime requirement. The values obtained by these different methods are quite arbitrary, the determinations being made under rigid standard conditions, if comparable results are to be obtained. No two methods give identical values for lime requirement throughout any considerable series of soils.

The amount of acidity as measured by these different methods is found to be considerable, yet, when the soil is shaken up with water and filtered, the clear extract obtained is nearly neutral in reaction, thus showing that only a very small amount of acid must be present in the soil solution, a circumstance which is explained by the insoluble character of the soil acids.

Chemists look upon acids from two points of view:—

1. The total or potential acidity.
2. The degree or intensity of acidity.

The meaning of the term total or potential acidity presents no difficulty, as it is simply the total amount of acid present in a solution, or, if insoluble, in intimate contact with the solution, and which can be neutralised by a base. Lime requirement methods such as that of Hutchinson and MacLennan aim at determining this acidity. But solutions may possess the same total acidity and yet show a very great difference in the intensity of their acidity. The quantitative expression of the intensity of acidity is based upon the electrolytic dissociation theory. According to this theory, chemical compounds, whose solutions conduct electricity, are partly broken up, dissociated, or ionised into electrically charged portions known as ions, when they enter into solution. Compounds differ widely in the extent to which they are dissociated, or ionised, in dilute aqueous solutions.

Many substances, including acids, bases, and salts, behave in this manner. A dilute aqueous solution of common salt—sodium chloride—is almost completely ionised into sodium ions bearing a positive charge of electricity and chlorine ions bearing a negative charge. All acids in solution in water are dissociated to a certain extent into hydrogen ions bearing a positive charge and other ions bearing a negative charge. Thus, sulphuric acid gives positive hydrogen ions and negative sulphate ions; nitric acid gives hydrogen ions and nitrate ions. It is to this hydrogen ion that the characteristic properties of all acids are due. An acid may be

defined as a substance whose aqueous solution contains hydrogen ions.

Water itself is slightly dissociated into hydrogen ions and hydroxyl ions, so that, in a vessel containing water there are undissociated molecules of water together with a certain very small proportion of hydrogen ions and an equal number of hydroxyl ions. The amount of hydrogen ions in pure water at 20°C is approximately 0.000,0001 gramme per litre or $1/10^7 = 10^{-7}$ gramme per litre.

A solution containing an equal number of hydrogen ions and hydroxyl ions is known as a neutral solution. The concentration of the hydrogen ions in a neutral solution will, therefore, be 1×10^{-7} gramme per litre. In a dilute solution of, say, hydrochloric acid the concentration will be much greater, *e.g.*, a centi-normal solution has a hydrogen ion concentration of approximately 1×10^{-2}.

This mode of expressing hydrogen in concentration is, for certain reasons, rather inconvenient, so it is now generally expressed by the symbol pH, which is the logarithm of the reciprocal of the hydrogen ion concentration.

A pH of 2 corresponds to a hydrogen ion concentration of 1×10^{-2} and a pH of 7 a hydrogen ion concentration of 1×10^{-7}. Thus a neutral solution has a pH of 7, an acid solution a pH of less than 7, and an alkaline solution a pH of over 7.

It has been mentioned that all compounds do not ionise to the same extent. This is specially true of acids. Normal solutions of hydrochloric and acetic acids will contain equivalent amounts of total acid, but the hydrogen ion concentration of the hydrochloric acid solution will be many times greater than that of the acetic acid solution, because the hydrochloric is almost completely ionised in solution, whilst only a very small percentage of acetic acid is ionised at the same concentration. Another factor governing the hydrogen ion concentration is the solubility of the acid. In the soil many of the substances capable of forming hydrogen ions in solution are of an almost insoluble character, and are only slightly ionised. It is, therefore, possible for a soil to contain a high percentage of acidic substances, and yet show a very low hydrogen ion concentration. During the last few years the problem of soil acidity from this point of view has been widely investigated.

North Wales soils, not containing excess of calcium carbonate, have a pH of less than 7. Those under cultivation are rarely below 5.0, whilst most of the ordinary fertile soils have a pH varying from 5.6 to 6.8. Thus the range of pH variation can be taken to lie

between 5.0 and 7.0. Is it likely that this acidity will exert an injurious effect on plant growth? Though certain plants develop better under slightly alkaline conditions, and others under slightly acid conditions, it would appear that the slightly acidic reaction corresponding to the ordinary pH of Welsh soils does not materially affect the growth of most of the common agricultural plants.

Experiments by Hoagland on the growth of barley seedlings in nutrient solutions of pH 5.0 showed that the acid reaction was in no way injurious to the plant. Salter and McIllvaine have shown that the optimum reaction for the growth of wheat, soy bean, and alfalfa, in nutrient solutions was a pH of 5.94.

Some of the methods for finding the lime requirements of soils consist in determining the amount of lime required to raise the pH to 7, but, from the foregoing and other considerations, it is by no means certain that neutrality is the optimum reaction for plant growth.

Buffer Action in Soils.

The pH of most of the fertile soils of North Wales varies from 5.6 to 6.8. It is found that when an acid or a base is added to one of these soils the change in the pH brought about by this addition is very small compared to the change in the pH of pure water following the addition of the same amount of acid or base. This property of being able to resist any attempts to change the pH is possessed by many substances.

Those capable of behaving in this manner are known as "buffers." For example, carbonates and phosphates act as buffers regulating the reaction of blood. In North Wales soils a very marked buffer effect is shown, so that any acids added to the soil will have very little effect on the pH. Sulphuric acid equivalent to 13 cwts. of sulphate of ammonia per acre was added to a typical North Wales soil of pH 6.6. This addition only reduced the pH to 6.0.

Lime water equivalent to 1½ tons of calcium carbonate per acre raised the pH to 6.9. It is, therefore, clear that such soils require very heavy dressings of lime to bring about appreciable changes in the pH. The amount of organic matter in the soil is closely related to the amount of buffer effect, which increases with increasing organic matter content.

From these remarks it will be gathered that the soils of North Wales are generally slightly acid in reaction and are very highly buffered. In view of these facts, and that it has not yet been proved that a pH of 7 is essential for optimum growth, it is clearly unsafe to use pH alone as the criterion for the need of a soil for lime.

Acidity with Neutral Salt Solutions.

When acid soils are treated with solutions of neutral salts, the extracts are of an acid character and contain in solution salts of iron and aluminium. This point has attracted considerable attention, and it is claimed that acid soils contain appreciable amounts of aluminium and iron in an easily soluble form. The infertility of such soils is held to be due, in part at least, to a specific toxic effect produced by excessive concentrations of these ions in the soil solution, or to the acidity produced by the hydrolysis of their salts in solution. Treatment of an acid soil with a neutral salt such as potassium chloride liberates free hydrochloric acid, which dissolves some of the easily soluble iron and aluminium compounds. Liming is supposed to precipitate this easily soluble iron and aluminium as insoluble compounds. In America, quantitative methods for the determination of lime requirements by the use of neutral salt solutions have been elaborated, whilst in this country a qualitative test devised by Comber is commonly employed. The lime requirements of North Wales soils according to these methods are small compared with the figures obtained by the Hutchinson-McLennan method. Except in the case of very acid soils no great amount of iron and aluminium is brought into solution on treatment with neutral salt solutions. Of the two elements, iron is probably present in the greatest amount. The Comber test demonstrates the presence of very small amounts of iron in a neutral salt solution in contact with soil. Negative results with this test show that the soil is sufficiently supplied with lime.

Positive results suggest that a further examination should be undertaken before advising on the need for lime, as soils which were distinctly acid by this test have failed to respond to liming.

Available Calcium Compounds in the Soil.

A characteristic property of infertile acid soils is the lack of easily soluble bases. So long as a soil contains excess of calcium carbonate, the supply of easily soluble bases, of which calcium is the most important, will be ample to supply the need of the plants and to neutralise the soil acids. But there are present in the soil calcium compounds other than the carbonate. Some of these, also, are leached out of the soil in the districts where heavy rainfall prevails. The agent primarily responsible for this leaching is carbon di-oxide, which is always present in the soil solution and the soil air.

It has already been stated that many soils entirely devoid of calcium carbonate, and capable of decomposing calcium carbonate, do not show any marked falling off in productivity. These soils are obviously unsaturated from the point of view of lime content,

yet they may possess a high percentage of relatively soluble non-carbonate calcium, which can furnish calcium ions in the soil solution. Calcium ions play an important part in plant metabolism, and in the soil solution antagonise certain other ions that are toxic to plants or bacteria and thus minimise the absorption of these ions in amounts liable to cause injury. Many attempts have been made to devise methods for estimating this easily soluble non-carbonate calcium. A method giving very definite figures has been worked out by Hissink. This method depends on the fact that when soils are treated with a solution of a neutral salt such as sodium chloride, part of the sodium of the sodium chloride enters the soil changing places with an equivalent amount of calcium which enters the solution. Each soil contains a definite amount of calcium replaceable in this manner. This calcium can also be extracted from soils with dilute solutions of acids or by continued leaching, with a solution of carbon di-oxide in water.

The amount of easily soluble, or available, calcium has an important bearing on the need of soils for lime. Some soils that have responded to lime have been shown to contain a low percentage of easily soluble calcium. On the other hand, soils acid by ordinary tests, but containing a fairly high percentage of easily soluble non-carbonate calcium, and therefore a higher degree of saturation, have not shown any crop increase on liming. It is possible that the need or otherwise of a soil for lime may be correlated with the difference between the amount of available calcium in the soil and the amount that would be present if the combining capacity of the soil for this base were completely satisfied.

In North Wales it is found that the available calcium content is much lower on upland than on lowland soils. This is due to the greater loss by leaching. In general upland soils would be considered more likely to be in need of lime than lowland soils.

An N/25 solution of carbon di-oxide in water has been found very useful for examining the availability of the soil calcium compounds. Soils showing an originally low percentage of easily soluble calcium by this method have responded to lime, and have shown after liming a greatly increased calcium solubility.

All the foregoing considerations show that the problem is very complicated. From the chemical point of view it has been thoroughly investigated, and it is only by carrying out field trials in conjunction with laboratory tests that any further progress can be made. A number of trials have been laid down during the last two years, but it is very desirable that many more should be laid

down in order to attempt to correlate the response to liming with the chemical factors mentioned.

The problem of soil acidity in its present position may be thus briefly summarised. Lime is undoubtedly needed on certain soils and is as undoubtedly superfluous on others. Between these extreme cases, where no doubt exists, lies a rather wide penumbra of doubtful cases where nothing short of actual field trials can demonstrate the need or otherwise for liming. The aim of modern work on soil acidity is to narrow down this penumbra of doubtful cases in order to be able to settle from laboratory examination whether liming is necessary, and if possible, to indicate the amount required.

Liming, with which we include the application of carbonate of lime, is a remedy against many soil defects, of which actual acidity is only one. Different crops require different soil conditions for optimum growth and response to liming may be due to one or more of the several changes consequent on the dressing. Sourness, using the word as a compendious term for all the defects remedied by liming, may consist in an acid reaction in the presence of active aluminium, in bad physical texture or in actual lack of available calcium. No single test can epitomise the position of the soil with regard to all these factors. In the typical soils of North Wales calcium carbonate is generally absent. They generally show a certain amount of potential acidity, but as the acids concerned in this activity are very insoluble, no great degree of acidity is shown by the soil moisture. Appreciable amounts of calcium are present in a non-carbonate form, and may in general suffice for calcium nutrition.

We may consider our soils as more or less unsaturated with respect to calcium. A moderate degree of unsaturation appears to be not entirely inconsistent with fertility. On the other hand, where responses have been obtained for liming, a high degree of unsaturation is shown. The more exact correlation of unsaturation with response to liming and the devising of a simple method for determining the degree of unsaturation of soils are the most immediate problems for solution.

Further, one must remember that the wet climate of North Wales causes a continuous desaturation of soils with respect to calcium, and that many soils which do not at present respond to liming are steadily losing their reserves, which are probably the residues from the generous applications of lime in bygone years. It may be desirable for the maintenance of fertility to forestall the inevitable depletion in calcium by reviving liming as an ordinary farm practice.

SOIL STUDIES ON THE WASTE LANDS OF LLEYN.

By H. Trefor Jones, M.Sc., and G. W. Robinson, M.A.,

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The study of types of natural vegetation has been developed very considerably during the past twenty-five years under the name of ecology. From these studies it has appeared possible to distinguish well defined plant formations, associations, and societies. Among the numerous ecological papers which have appeared, few, if any, give more than merely qualitative data as to soil conditions, a circumstance which is perhaps not altogether surprising, considering the somewhat chaotic condition of soil analysis.

Messrs. R. Alun Roberts and John Rees of this College, from their ecological studies in West Carnarvonshire, have distinguished and mapped the different types of natural vegetation in the waste lands of the peninsula. It seemed an interesting and, possibly, profitable task to examine the soil conditions associated with some of their principal types, in order to discover what, if any, are the soil factors controlling natural vegetation, and, further, to obtain data which might be of value if at any time it is proposed to improve the waste lands of this area.

In consultation with Mr. R. Alun Roberts, we accordingly selected a number of types for close examination of their related soil conditions. The following types were selected for examination[1]:—

Heath, Rhos, Gorse, Bog, Fen, Marsh.

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[1] Note by Mr. R. Alun Roberts, B.Sc., on the vegetation types referred to in the present article.

Heath develops on the poorer and lighter soils on hill slopes. Drainage is very pronounced and in the main there is evidence that the area now occupied by heath was formerly woodland. The grass is largely sheep's fescue and bent grass, whilst the scrub flora is in the main hawthorn and gorse (*Ulex Gallii*).

Rhos. On more level stretches and heavier soils, rhos appears. Peat, which has accumulated on the surface, was in the past pared off and burnt as fuel, leaving a scanty surface layer over cold impervious clay. The ground easily gets water-logged, is poorly aerated and is characterised by a close growth of *Ulex Gallii, Erica Cinerea* and *Molinia Coerulea.*

Gorse. This type is characterised by the presence of gorse (*Ulex Europaeus*), which was at one time exclusively sown for fodder. The practice has now largely fallen into disuse and outlying grassland on many farms is falling into scrub gorse with an under cover of bent grass and cocksfoot. This formation merges into heath at many points.

Messrs. Roberts and Rees distinguish a number of sub-types of each formation, but we have generally studied the soils associated with the main types only.

In the space at our disposal it is not possible to present the very copious data which were obtained during the investigation. We shall only attempt to set forth the principal conclusions at which we have arrived.

In the first place, we have endeavoured to discover to what extent differences in natural vegetation could be correlated with conditions observable in the field without recourse to laboratory investigation. There is, of course, the immediate and obvious division of the types into dry and wet types. Heath, rhos and gorse form the dry types, whilst bog, fen, and marsh form the wet types. The former generally occur in uplands and on slopes whilst the latter are found in the lowlands and valley bottoms. It would appear that, of the three dry types, gorse is the driest and rhos the wettest. At the same time, it may be that, physiologically, heath and rhos may be drier than gorse, at any rate, during the summer months. Heaths are generally found at higher levels than rhos and gorse, and appear to be situated usually on open textured sedentary soils at no great distance from the underlying parent rock. The rhos soils are, for the most part, flat stretches of rather heavy glacial soils from which turf has been cut for fuel in former years. They would appear to alternate between excessive wetness in the winter months and, under normal conditions, excessive drought in the summer. With regard to the gorse soils they appear to be much more favourable to plant growth and it is not easy to see why they are not more utilised under cultivation.

Of the wet types, fen is much the wettest. It is represented by the lowest portions of Gors Geirch near to Rhydyclafdy. Marsh appears to be characterised by waterlogging in the winter, whilst in summer it becomes drier owing to sinking of the water table. Marsh soils

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Marsh. The area contains no extensive stretches of marsh. The fen area merges into marsh. Where marsh occurs elsewhere, it owes its existence to defective drainage on flat surfaces. On draining, it generally passes to good grassland or meadow, from which, by accumulation of water it has retrogressed.

Bog. This type occurs as wet pockets with peat accumulation at the foot of dry heath formations, which readily drain into it. There is nowhere in the area any extensive development of moor, but the bog lands have a fair moorland population amongst their heath flora.

Fen. True fen, characterised by such plants as *Cladium Mariscus*, occurs at one point only, in the low-lying Cors Geirch, a wet basin between Rhydyclafdy and Nevin. It is a tract of deep peat, presumably fed by waters containing mineral matter in solution.

would never, as is the case with rhos and heath soils, suffer from drought since they occur in lowland situations. Bog types appear to be less wet than fen. Both bog and fen are peaty in character, but whilst bog is apparently a land formation, fen is of aquatic origin.

With regard to the texture of the different types as revealed by mechanical analysis, the only definite point to note is that rhos soils are distinctly heavier than the others. This was obvious in the preliminary observations in the field. It may be that the distinctive nature of rhos is connected with this character, for the waterlogging consequent on poor natural drainage might be expected to produce peat. This has been the case, but the peat has generally been removed for use as fuel, leaving a profile in which a thin peaty layer is succeeded by a raw subsoil. In the more open textured heath and gorse, peat is not so apt to develop and with the better drainage, root development is not so restricted to the immediate surface layers. A consequence of this is that the organic matter content falls off more gradually from the surface downwards.

Samples of soil from the various types were taken at different times with the object of comparing their moisture contents. The distinction between the dry and wet types was at once apparent, as might be expected. Of the dry types, gorse was generally the driest, as had already been indicated by field observations. Rhos is generally wetter than heath. We have unfortunately had no opportunity of obtaining data during a period of drought. Such data would have been of particular value, because it may well be that such periods are critical in determining the nature of the vegetation on soils.

Although we have generally found gorse soils to be drier than heath and rhos, it seems likely that they are less subject to extreme drought than the two latter types. The vegetation of heath and rhos consists generally of plants which might be described as poverty species, able to exist with scanty supplies of plant food and to withstand occasional spells of extreme drought. Gorse is a semi-cultivated type comprising species which make greater demands on plant food and require less rigorous moisture conditions.

The chemical examination of the soils of the different types is chiefly of interest where it concerns those factors which govern the reaction of the soil and its deficiency or otherwise in lime. With regard to the ordinary elements nitrogen, phosphorus, and potassium, supplied in fertilisers, we were unable to trace any connexion between their occurrence and the prevalence of any particular type of vegetation. Nitrogen is generally associated with organic matter

and some of the highest nitrogen contents were found on the poorest soils. Potassium is generally present in quantities more than enough for vigorous plant growth except on very sandy soils, which do not come within the range of the present enquiry. Uncultivated soils are almost invariably deficient in phosphorus, judged by the standard of cultivated soils, but we were unable to discern any regularities as between the different soil types.

The results of our work on the reaction and lime status of the soils are more helpful to us in our attempt to find a basis for distinguishing the different soil types. Briefly, it appears that the upland soils are generally deficient in lime whilst the lowland wet types, though never containing appreciable quantities of calcium carbonate, nevertheless contain quantities of available lime in the form of complex humates and aluminosilicates. This is reflected in the reaction of the soil moisture. Whilst the upland soils are generally very decidedly acid, the lowland soils are nearer to the neutral point and sometimes, as is the case with certain fen soils, actually alkaline.

In the earlier work on the question of lime and soil acidity, attention has generally been focussed on the presence and amount of calcium carbonate in the soil. It has been generally assumed that calcium carbonate is a necessary ingredient of fertile soils and that its absence implies deficiency of lime. Recent work has shown that considerable amounts of calcium may occur in the form of the complex humates and aluminosilicates mentioned above. The calcium of such compounds is active or readily available and may play a similar part to calcium carbonate in regulating soil reaction. The calcium of these compounds is sometimes referred to as "adsorbed calcium" but it is perhaps simpler to regard it as combined with the complex colloidal organic and inorganic matter present to a greater or less amount in all soils.

We regard this complex colloidal matter as being potentially of an acid character. In soils containing an excess of calcium carbonate these insoluble acids are neutralised and are present principally in the form of their calcium compounds. In soil devoid of calcium carbonate, such as our typical Welsh soils, the potential acidity of these complexes is only partly neutralised. On account of their insolubility, these acidic materials do not give rise to a marked acidity provided a certain amount of calcium is present. Thus, although a soil may be unsaturated in the sense that its potential acidity is not completely neutralised, yet the complex calcium compounds are present in sufficient amount to furnish calcium to plants and to maintain soil reaction within the limits favourable to plant growth.

The complex calcium compounds to which we have alluded are distinct from the calcium minerals such as the lime felspars belonging to parent rock material. The calcium of such silicate minerals is highly insoluble and is of importance only as a reservoir from which calcium may ultimately be liberated by secular weathering.

We recognise, then, that soils such as those of North Wales which do not contain calcium carbonate may nevertheless contain active or available calcium in the form of the complexes which we have just described. In our very wet climate, soils are constantly being washed through with water which carries with it material in solution. The available calcium of soils has a certain solubility and with the constant leaching to which it is subjected the soil becomes desaturated with respect to its available calcium. This results in an increase in potential acidity. This has been the case with the upland soils such as the heath, rhos and gorse types. In such soils, not only do we find no calcium carbonate but the content of available calcium is generally very low. At the same time these soils with their large amount of humic matter have considerable potential acidity. Of the three upland types, the gorse soils are probably least unsaturated.

In the lowland soils on the other hand, although they are similar to the upland soils in containing no calcium carbonate, there are appreciable quantities of available calcium, and although they may in some cases show a small degree of unsaturation, yet this is not likely to be enough to give them a marked acid reaction or to result in a scarcity of calcium for plant food. One may conjecture that the upland soils have been robbed of their available calcium by leaching and that this calcium has been added to the moist lowland fens, bogs, and marshes where leaching is relatively slight owing to the proximity of the water table. With their considerable supplies of available calcium and their neutral reaction, it would seem that many of these lowland soils might be of considerable fertility if they could be improved by drainage. On the other hand the upland soils are not likely to be suitable for cultivation or even for improvement as grazing until their deficiency of lime has been made good. Judging from the composition of the cultivated soils of Lleyn, one would imagine that they still retain residues from dressings of lime given in past years. But a steady depletion is proceeding and it may be safely asserted that permanent productiveness cannot be maintained at a high level without liming. The lack of response to lime which is sometimes noted may be due to the generosity of preceding cultivators of the soil. Whilst much of the soil of Lleyn is now in need of lime, more will come to that condition in the future.

unless that undesirable state is forestalled by the intelligent application of suitable dressings. Our observations would lead us to expect that this impoverishment in lime is more likely to have proceeded to the point of depressing fertility in upland well drained soils than in lowland soils, where some accumulation of lime may take place.

The differences in natural vegetation in this area appear to be ultimately connected with situational factors. The nature of the soil itself appears to be of secondary importance. In fact, as a general rule in the area we have investigated, the nature of the soil itself appears to be secondary to situation, although we may perhaps make a reservation in the case of the rhos soils where the heavy texure of the parent material has affected the resultant soil and vegetation.

The character of any soil is governed by the character of the parent material and by the processes of soil formation, which are mainly controlled by situation and climate. We must also allow an effect of natural vegetation on soil, in the case of the organic matter. Leaving out the coarse sands, which we have not studied, the parent materials of our soils are not so diverse as to impress their characters on the resultant soils. This is, of course, a local circumstance for if there were any considerable area of limestone it would be reflected in soil and vegetation, as is seen in the case of the limestone of the Llandudno district and parts of the uplands of Flintshire. In Lleyn the natural vegetation is mainly the reflection of situational factors.

THE AERATION AND DRAINAGE OF SOILS.

By J. C. Newsham, F.L.S.,

Monmouthshire Agricultural Institution, Usk.

A study of British Flora reveals the wonderful adaptability of plants for varying soils, as well as climates. The average cultivator does not always realise the relationship between certain plants and the moisture content of the soil. Truly aquatic and even semi-aquatic plants are of little economic value, being mostly of rank growth and unnutritious. Such plants are represented by rushes, sedges, and the many species or varieties of plants found growing in neglected water-meadows and wherever the soil has been allowed to become water-logged or stagnant. Excess of moisture is usually detrimental to flower and seed production, and, therefore, the majority of plants which frequent water-logged soils are usually

coarse and succulent in growth as compared with those which are indigenous to the drier soils.

Much of the pasture land throughout the valleys of Wales is naturally drained, although here and there comparatively large areas remain in a more or less water-logged condition during the greater part of the year, with the result that herbage of an undesirable character takes the place of the finer and more nutritious plants and grasses.

High class or intensive cultivation, if attempted on the more retentive soils, cannot be successfully conducted unless strict attention is given to the question of drainage, as unless the soil is well aerated, and admits of the free circulation of air between its particles, the temperature remains low, and early as well as good crops cannot be produced. Market gardeners as a class possess an intricate knowledge of the propagation and cultivation of plants, and to be successful must obtain the maximum yield from a given area of land, which is only possible when ideal soil conditions prevail. This does not necessarily mean an elaborate system of pipe drainage, as in many instances the planting of roots on ridges, the earthing up of potatoes, strawberries and other plants, as well as the opening up of surface water furrows, and more particularly the systematic liming and sub-soiling of land comprise some of the operations associated with successful cultivation.

Similarly, many years ago, when the heavy or woodland soils were under the plough, even a vigorous growing crop like wheat could only be successfully grown where "five-turn" or narrow lands with deep furrows allowed the soil to be thoroughly aerated and drained. Now that much of this soil has been thrown into larger lands, more or less level, it naturally follows that a water-logged condition has resulted, making an efficient system of drainage absolutely essential. Fully 80 per cent. of the low yields of crops in this country may be traced to bad soil conditions rather than to lack of fertility.

While rivers and tributaries provide a natural source of drainage, complicated and expensive schemes have to be devised from time to time for draining large areas where no natural means exist for diverting or drawing off surplus water, and notwithstanding the existence of such schemes, the areas so drained may still be subject to periodical flooding.

In South Wales, one of the most important undertakings in connection with the drainage of agricultural land is that of providing efficient water courses and reens to secure the proper drainage of low-lying areas bordering the Bristol Channel, and at the same time

to effectively resist sea-encroachment. As in other parts of the country, this scheme is in the hands of a special authority, known as the Commissioners of Sewers, first established in the reign of Henry VIII, and now regulated by Drainage Acts, 1861 and 1884. The necessary funds for this work are secured by means of (1) a rent charge on the owners of the lands liable, (2) an ordinary annual level rate for general charges levied on occupiers, and (3) an extraordinary storm rate also levied on occupiers. In Monmouthshire, the districts referred to comprise the Level of Caldicot on the east side of the River Usk, and the Level of Wentlooge on the west side; the former reaches from the River Usk to Chepstow, and comprises 15,682 acres—the length of sea-walls and banks is about 22 miles, of reens, sewers and water-courses 115 miles, and ditches 475 miles. The Level of Wentlooge contains about 8,148 acres, and bordering this are 18 miles of sea walls and banks, and there are 46 miles of reens, sewers and water-courses therein.

Without some such scheme the property in low-lying districts would be valueless, and thus it became necessary to establish a scheme by which these lands should be protected from sea-encroachment and in-land flooding.

Apart from the levying of the rates in the districts concerned, these extensive schemes do not concern the average farmer or cultivator, neither is it usual to employ the larger and more expensive types of machinery in connection with farm drainage, such as dredgers or excavators for cutting out ditches, which are usually worked by steam power and propelled by different devices. Some of these dredgers are floated along the drainage ditches, which gives them additional freedom of motion. Efforts have been made at different times to perfect an implement, such as that known as the mole plough, which may be drawn by power through the soil at the desired depth, thus forming a continuous channel in the subsoil by simply pressing it aside. Channels so constructed, however, are very soon obliterated or choked, thus rendering them of little practical value, and although some of the more improved methods of machine drainage are to be commended for consideration by those who contemplate carrying out a somewhat extensive scheme, the system of pipe drainage is still the most effective in the draining of ordinary fields.

A difficulty often encountered in draining certain areas of land is that of not being able to secure a sufficiently good fall within the immediate area of operation, where the fields to be drained form, as it were, the bottom of a basin. Perhaps the chief difficulty to contend with to-day is that of securing competent or efficient drainers,

as it would appear that this work is now mostly done by amateurs, who have no expert knowledge. On this account, much of the work must necessarily be faulty, whereas years ago it was a comparatively easy matter to obtain a satisfactory price for the efficient draining of any given area.

Owners of agricultural land who contemplate embarking on a drainage scheme can obtain reasonable financial assistance through the medium of the Ministry of Agriculture and Fisheries on application to the County Agricultural Committee, who would be responsible for the carrying out of the scheme. Two-thirds of the cost would be borne by the Ministry in approved cases, the remaining one-third having to be paid by the land owner within six months of the satisfactory completion of the work.

In considering the drainage of any particular field the arrangement of the main drains is of first importance, and can be readily determined when it is understood that the smaller drains should be parallel to each other, and running in the direction of the greatest inclination, or as near as circumstances permit. Each plane or declivity of which the field may consist must be divided into its set of drains, including a main drain, placed in such a position as to receive the water from the smaller ones that are near the bottom of the plane or field as the case may be, and made sufficiently straight, and with such a fall, as to carry off the water with facility to the outlet.

Where a field slopes in one direction, it may be effectively drained by one set of drains, unless it is of unusual length or encumbered with high ridges running in various directions. It will require only one main drain at its lower end, unless it is widest at its upper end, in which case a second must be made along that side where the ridges run into points. A main drain is usually necessary in each hollow of any considerable extent, and at the bottom or any side of the field to which water may incline. These hollows sometimes run parallel to the sides of the field, while in some cases they are more or less at right angles thereto, and thus a main drain carried along their bottom usually serves for the plane on each side. Should a hollow continue through an adjoining field without a ditch the main drain would probably require to run through it likewise until it arrives at some suitable outlet. Rarely is it satisfactory to run each small drain separately into the open ditch at the side or bottom of the field, as this results in stoppages and flooding, and accounts for wet patches and loss of plant so commonly observed on many farms during the early spring months. There can be no doubt that the ditches and open water courses on many farms are not kept suffic-

iently well scoured, with the result that there is much backing or holding up of water, which would otherwise find an exit.

The depth of water in main drains is often considerable, and the level thereof, if not prevented, will extend to some distance in the small drains. For example, if the depth is two inches, the main drain would need to be three or four inches deeper than the others to effect the desired result. Similarly, the ditch should be deeper than the outlet of the main drain, according to the quantity of water therein. Thus serious mistakes are often made in not sufficiently deepening the lower ends of the main water courses, which is most essential if the land is level in the direction in which the smaller drains are laid. If, on the other hand, the fall of the main and small drains is sufficient, it is not essential to make the former deeper than the latter, but it is preferable to make the outfall ditch considerably deeper, rather than to make the end of the main drain too shallow, seeing that its rate of fall is thereby diminished, and its structure rendered more liable to injury.

In wet and low-lying districts, where flooding is common, the importance of a good outlet is essential, and when obtained the main drain should be held responsible for dealing with a large area of land, so that the number of outlets depending upon the state of the stream or brook may be reduced to the minimum. When the land is flat and the lower part thereof is at a distance from a stream, and when the area is not of such an extent as to require an open ditch, the proper position of the main drain should be carefully ascertained by means of a level, and the exact rate of inclination which can be obtained should be registered, so that it may afterwards be used in carrying out the fall of the bottom somewhat accurately, and for such other purposes as it may serve.

Longitudinal drains possess an advantage, inasmuch as they are cheapest, the water is conveyed at a rapid rate and admits of much smaller tiles being used. The length of the main drains, which are more costly than others, is less on the average, and the cost of twice draining the land within the influence of the main drain on each instead of on one side is also in most cases avoided. They are most permanent, because each drain receives its water alike from both sides, and its own share of that contained in any strata cropping out across the field, and is in the best position to convey it rapidly away. The entrance of water into the drains is as far as possible equalised throughout the field, and no drain is liable to any sudden or large accession thereof to carry injurious water into it.

When it became necessary to grow as much corn and as many arable crops as possible during the war, the tendency was to throw

small arable as well as pasture fields into one large area of arable, thus effecting economy in labour and machinery, but in doing so many of the natural water courses were interfered with, and where underground pipes are not laid, much of this ground is now ineffectively drained. Therefore, careful consideration should be given before dispensing with any water courses, which, although dry in summer, may serve as water carriers during the winter or times of flood.

There is no difficulty in causing water to descend to any depth through the material above the pipes, it is only necessary that it should be porous to ensure this result. Gravity will propel water downwards if the smallest opening exists through which it can pass, but there is the difficulty of procuring the contraction of clay to an extent corresponding to the depth of the drain, after the latter reaches a certain depth from the surface, greater or smaller according to circumstances. In the stiffest kind of subsoil, if situated in a wet locality, difficulty is experienced in opening the clay and keeping it open to the depth requisite for efficient tillage, unless careful means are taken to attain that end by filling in above the pipes to within eighteen inches of the surface with stones, porous earth, or other suitable material, in order to promote shrinkage of the clay and to pass water down to the pipes.

In perfectly porous soils, resting at a considerable depth upon clay, drains act merely in conveying the water which filtrates through them, and the deeper they are cut until reaching the stiff clay the greater will be the distance from which they draw water. The deeper the bed of earth they drain, the further they must be placed apart, as water will sink through all parts to the level of their bottoms. The subsoil, being porous, will enable it to find its level speedily by flowing horizontally.

When the soil and subsoil are of a tenacious character the first effect of the drains must be to establish and maintain that degree of porosity which will enable water to sink to the greatest attainable depth between the drains, and to be at once drawn diagonally downward without check. The water cannot be made to sink to an equal depth as in the former case; the clay mid-way between the drains is not made porous to their depth. Hence calculations of the bulk of stiff soil made dry by deep drains, based upon the idea that all parts thereof are made porous to the level of their bottom, must necessarily be fallacious.

Unfortunately the pipes or tiles employed in draining clay and other soils are often placed at a distance much too great to effect thorough drainage, whatever may be the depth adopted, and this evil,

instead of being corrected by experience, is still very common and amounts to so much false economy, seeing that subsequent operations are essential for good cultivation, and depend entirely upon the efficiency of the drainage system.

The fact that water-logged and marshy land gives origin to some of the most dreaded diseases among domesticated animals, as well as affecting the growth of cultivated plants, is often overlooked. Injurious germ life and insect pests of the most virulent type are afforded an opportunity of thriving and reproducing themselves in swamps, but the efficient drainage of these creates an atmosphere within the soil no longer favourable to their existence.

NOTES ON HORTICULTURAL RESEARCH AND DEVELOPMENT.

By W. G. Lobjoit, O.B.E., J.P.,

Controller of Horticulture, Ministry of Agriculture.

It is sometimes said that agriculture in this country is governmentally neglected. This can only be true at the most in a comparative sense and that comparison must be made in respect of some particular policy or scheme which those who make the charge think should be carried out.

So far as that division of Agriculture, called Horticulture, is concerned, the position as to Government fostering stands thus:—

County—

Horticultural Superintendents and Instructors.

No. in England—70 in 43 counties.

No. in Wales—14 in 12 counties.

(Many are part-time employed only.)

Also 3 in Lancashire (not aided by Ministry).

Counties where none appointed—3 (Bedford, Kesteven, Peterboro').

Number of Farm Institutes—

Ten (7 England, 3 Wales).

Nine under Local Education Authorities.

One (Chadacre, Suffolk) a private institution.

Also eight Demonstration Farms, without Farm Institutes, which may come later in certain cases.

PROVINCES—

No. of Advisory Officers—44 attached to 14 centres (of which 11 are in England and 3 in Wales).

No. of Provincial Conferences—A total of 14 held in 1922-23 (excluding the meetings of the Welsh Agricultural Education Conference).

Advisers and Ministry's Advisory Staff—

Ministry's Advisory Staff at the Ministry's Pathological Laboratory at Harpenden—4.

No. of Higher Technical Men at Research Institutes (at 18 Institutes)—99.

Research Stations—Horticulture.

Rothamsted	Plant Nutrition.
Harpenden	„ Pathology.
Cambridge	„ Breeding.
Long Ashton	Fruit Growing.
Malling	„ „
Imperial College of Science ...	Plant Physiology.
Waltham Cross	Greenhouse Culture.

MINISTRY'S OFFICERS.

In the administration of the D.I.P. Orders, many opportunities occur for work of an advisory or educational character which is done in co-operation with the County Officers.

This arrangement is designed to place the latest knowledge, the newest conclusions of science, the most recent results of experiments, as well as records of practical experience gathered from all over the world, at the service of practical cultivators who are contending in the front line with all the difficulties attendant on producing food from the soil, and making a living by the occupation; an achievement that indeed requires as high grade amalgam of human qualities as any occupation under the sun. At the same time this organisation provides means by which any problem of the soil, or of soil treatment, or of plant culture, or plant pathology or physiology, however obscure, however long and intricate may be the research its solution demands, can be entrusted to experts competent for the particular class of investigation needed, or to "team" work, where the problem spreads itself across more than one line of research. Now this, it will be admitted, is a provision which is well conceived and generous on the part of the State and the co-operating local authorities. It is mobile, as it needs to be, continually being elaborated and extended. The opportunities offered are at the

service of every class of cultivator, from the allotment plot to the largest commercial concern. What is the justification for this public expenditure in the interests of one industry? What can Horticulture offer to the community in return for this educational machinery on its behalf? The days of anxiety during the years 1916-18, when starvation stared the people of this country in the face because the provision of home-grown food had been allowed to contract in area and in amount, is now nearly forgotten, or the question would answer itself.

The horticultural industry is the greatest wealth creator in the country. It does not use up resources as, for instance, coal-getting does, so that one may say " in so many years there will be no more." It makes just that contribution of human thought and endeavour which provides the medium through which nature can perform her miracles. It does not use up the land; it uses it. The longer that horticulture has the soil under its control the more fertile it becomes. The products of the horticultural industry, as also of agriculture in general, are clear addition to the national wealth, without any discount, with this distinction,however, that horticulture produces the greatest amount economically possible from the land, gives the largest amount of employment on the land, and, at the same time, encourages and supplies the most healthy of appetites. It co-operates with far-seeing statesmanship, is the ally of education and the auxiliary of every worker for the improvement of health and morals.

What of the condition and prospects of this industry? It is the one part of agriculture that, whether in periods of deepest depression or moments of comparative prosperity, has continued to expand. It is faced with greater intensity of competition from lands over the seas than almost any other industry. It is courageously organising itself to enable it to perform its vital national service. It has laggards and Rip Van Winkles among its ranks. There are obstacles that can, and should be, removed, and there are stumbling blocks tolerated and even blessed by the industry itself. There is need for education and enlightenment. But the industry holds out a warm welcome to the scientific expert and is ready to assimilate any new knowledge that is brought to it. Horticulture stands for that intensive cultivation which must one day, of necessity, be practised on every yard of cultivatable soil. Far-seeing people are already impressed with the growing encroachment of the world's ever increasing population upon the sources of the world's food supply, and that, despite the present ephemeral super-abundance of food.

There are still areas in England capable of development horticulturally which wait for the cultivators to apply the necessary capital and labour; but it is even more the case in Wales. It is astonishing that, with its teeming population gathered to exploit the mineral wealth beneath its surface, there should be so little horticultural development alongside. Along the banks of the estuaries of the South Wales coast there is a climate and there is land that could be developed for the production of early potatoes and other vegetables that will greatly add to the national food supply, and provide for the people of South Wales fresher supplies of these important foodstuffs than they at present can secure, transported, as they must be, from long distances. Much land, now given over to the least productive form of agriculture, namely, cattle raising, could, if the men were there with the gardening instinct, and the necessary knowledge to enable them to practise the art of the horticulturist, be made to turn out ten times the weight of food, giving employment to many more families on the soil, at the same time providing new sources of health-giving produce.

There is a Farm Institute at Usk where the great possibilities for horticulture are demonstrated in a practical manner, with eminent success.

Scattered over the counties there are demonstration plots established by County Officers with the goodwill of farmers, that, though but recently started, have already pushed the door ajar, and let light in to see what might and what can be done.

There are individual undertakings, including some County Council Small Holdings, which show what individual initiative armed with knowledge, industry and capital, can do to increase production, with profit, to the cultivator, and benefit to the community.

RECENT RESEARCH IN FRUIT CULTURE IN THE BRITISH ISLES.

By Professor B. T. P. Barker, M.A.,
Director, Long Ashton Fruit Research Station.

The production of fruit for market purposes has gradually but very definitely in recent years become a matter for the specialist. The commercial fruit grower has found that under the stress of foreign competition and a variety of other causes divided attention between that form of culture and other branches of farming does not in general pay and that fruit growing under modern conditions

cannot be treated merely as a side line to general farming. It calls for special knowledge and skill and it has its own problems which can only be met satisfactorily by a combination of experience and intimate touch with the most up-to-date methods and the results of research. Such reasons have undoubtedly played their part in determining the distribution of commercial fruit growing in this country. It is by no means a matter of soil and favourable local conditions only that is responsible for the greater part of the commercial fruit area being centred in a few particular districts, such as Kent, Cambridgeshire and the Vale of Evesham. At the same time, while recognising the importance of suitable local conditions in those localities, the intending fruit-grower need not feel bound to start in those regions, for it is beyond question that there are many parts of the country well suited for fruit culture which have not hitherto been taken into serious account in that connection. Nor, if he is sufficiently enterprising, need he be discouraged from settling in a district where there is little local experience to serve as a guide. Valuable though the latter is, it is not indispensable, for many facilities to secure technical advice now exist which were not available for the earlier generation of commercial growers. The County Agricultural Staffs, the Agricultural Colleges and Advisory Centres, and the Fruit Research Stations form a combination which should suffice to enable anyone to start on sound lines and avoid serious blunders.

The object of this article is to indicate briefly the lines on which recent research in this country has been proceeding, so that both established and prospective growers may be informed as to subjects on which the Research Stations are in a position to render assistance. Since in most cases the investigations are still proceeding, there are necessarily many subjects upon which complete information cannot yet be given. Generally speaking, even in such instances the grower can be materially helped.

Until comparatively recent times there has been little organised research in fruit culture in this country. The establishment of the Experimental Fruit Farm at Woburn by the Duke of Bedford in the latter years of last century with the late Mr. Spencer Pickering as Director of the scientific work, may be taken as marking the beginning of modern effort. This Station was recently closed, but much valuable pioneer work was done there, particularly with regard to the effect of grass on fruit trees, methods of planting and pruning, and the control of various pests and disease by certain spray fluids, such as caustic winter washes and Bordeaux mixture. In 1903 at Long Ashton, near Bristol, what now serves as the Fruit Research Station

of the University of Bristol began its career under the name of the National Fruit and Cider Institute. In due course there followed the development of Wisley by the Royal Horticultural Society and of the John Innes Horticultural Institution at Merton, Surrey, at both of which investigations concerned with fruit culture are included in the programmes of work. In 1913 work began at the East Malling Fruit Research Station, Kent, where the pomological investigations hitherto carried out at the South-Eastern Agricultural College, Wye, in that area have been considerably supplemented and extended. Since the war horticultural research has been developed at Cambridge University. At various other centres throughout the country there are interesting and instructive field experiments in progress. The assistance of science for the fruit grower is thus being provided now on a relatively extensive scale.

The work at these Stations covers a very wide field and its nature can only be indicated in a very incomplete way within the limits of this short article.

Naturally attention is being devoted to the question of suitability of soils for fruit culture. There is in progress a survey of fruit soils conducted jointly by Cambridge and Bristol Universities and this has already furnished results of fundamental significance for the fruit grower. Closely related is the subject of the nutrition and manurial requirements of fruit trees. The examination of the action of the various essential elements of food is under investigation at Long Ashton, while there and at numerous other centres manurial trials are being conducted.

Important as are soil conditions and nutrition in affecting the health of fruit trees and the balance between growth and cropping there are many other factors combining to determine the ultimate result. Among such are climatic conditions, root-stock influence, pruning, and cover-cropping. The investigation of their action is not being neglected.

At Long Ashton, East Malling, Wisley, and possibly other centres, an elaborate scheme designed to elucidate the effect of weather on the behaviour of fruit trees is being started. The problem of root-stock influence is a very complex one and is being attacked from several directions by the Long Ashton and East Malling Stations. They have been associated in the examination of apple stocks, the former dealing primarily with "free" and "crab" seedling forms and the latter with "Paradise" types. East Malling has also extended its studies of this character to other kinds of tree fruits. The importance of the methods of pruning adopted in determining the balance between growth and cropping is universally recognised,

but considerable difference of opinion has existed as to the best form. Experiments on this subject have been widely made with varying results. Their outstanding contribution to knowledge has been not so much the establishment of any one method definitely superior to others as the clear indication that the nature of the response of the tree to any method depends upon local conditions and the character and state of the tree itself. The principles of pruning for crop production are now better understood and the value of special subsidiary methods for bringing infertile trees into bearing, such as bark ringing, which has been a subject of special study at Long Ashton, is more fully appreciated. Cover-cropping, a practice widely practised in America, is of double interest in this country. The function of the cover-crop as a green manure is of particular interest in view of the increasing difficulty over supplies of farmyard manure to serve for organic manuring, but the direct effect of the cover-crop in competition as a crop with the trees themselves is a point of great importance. So far cover-crops from the former point of view have not yet been investigated thoroughly in this country, but in their latter aspect Pickering's work at Woburn on the effect of grass on fruit trees is intimately connected. His work is being followed up at Long Ashton, for it appears to be clear that while the toxic effect of grass on the trees is pronounced under some conditions, under others the checking influence on tree growth has the beneficial effect of bringing the tree into bearing without material injury to its general health and vitality.

Comparative trials of the merits of individual varieties of the different kinds of fruit have been made or are still in progress at several centres. East Malling has been particularly identified with the classification and trials of varieties of black currants and is associated with Long Ashton in corresponding work on raspberries. At the latter Station strawberry variety trials have also been for some time in progress. At Wisley a comprehensive scheme for testing recently introduced varieties of our hardy fruits has lately been established.

While there are in existence already varieties of high standard with the necessary characters for commercial success in the case of most of our fruits, there is still much room for improvement. At present for most kinds of hardy fruits there are serious gaps in the succession of varieties to cover the full season with sorts which combine excellence from the commercial point of view and high quality for the consumer. The breeding of new varieties is therefore proceeding extensively, particularly at Merton and Long Ashton. At the former Station and Wisley such work has been associated

with a study of the problems of fertilisation and the self-sterility and self-fertility of varieties.

Research on the production of healthy and profitable trees inevitably involves investigations on the various diseases and pests to which the individual kinds of fruit are subject and on methods for their control. Complete enumeration of all the work under this head is impossible here and the following record deals only with some of the commoner diseases and pests, concerning which enquiries are perhaps most frequently received.

Of the fungoid diseases, Silver-leaf is under investigation by Brooks at Cambridge, blossom wilt and other Monilia diseases by Wormald at Wye and East Malling, canker, scab and various die-back diseases of the apple, pear and plum at Long Ashton, and Diaporthe die-backs by Miss Cayley at Merton. The work of Salmon at Wye on fungoid diseases of fruit trees, extending now over many years, is well known, particularly his contributions to our knowledge of American Gooseberry Mildew and other mildews.

As regards insect pests, Theobald's sudies at Wye on the life histories of various Aphids and many other forms have covered a wide field and have been supplemented elsewhere by the researches of other workers, such as those of Fryer and Petheridge on Capsids at Harpenden and Cambridge, of Miles at Long Ashton and Massee at East Malling on apple blossom weevil, on codlin moth by Butler at the Imperial College of Science, on big bud of black currants at Long Ashton and East Malling, and the raspberry and logan beetle at Long Ashton.

Control measures against diseases and pests have been investigated at many centres. For examples, the mode of action and efficiency of sulphur, lime sulphur and ammonium polysulphide, Bordeaux mixture and other copper fungicides, stomach poisons, including the various arsenic washes against leaf-eating caterpillars, and egg-killing winter washes of the Carbolineum type have in recent years been examined both by experimental work in the laboratory and by field trials.

Reference may also be made to the researches on some of the obscurer troubles and diseases, the causes of which in some cases are not yet fully established. East Malling, for example, is con-concerned with the " running off " and reversion diseases of black currants and the mosaic disease of raspberries, while at Long Ashton, in addition to black currant reversion, " red plant," blindness, and other diseases of the strawberry plant, and " leaf scorch " are being closelv studied.

Supplementing research work on fruit culture, the problems involved in the disposal and use of the crops are not being neglected. The Food Investigation Board is responsible for experiments and trials on methods of storage of fruit at the Low Temperature Research Station at Cambridge and at Long Ashton. The University of Bristol has at Campden, Gloucestershire, a research station concerned with methods of fruit preservation.

Incomplete though this review of recent and current scientific effort for the benefit of the fruit grower is, it may suffice to indicate both the variety of subjects which call for attention and the prospect of material help in his difficulties on a scale much greater than at any time previously.

POLLINATION IN ORCHARDS.

By F. J. Chittenden, F.L.S., V.M.H.,

Director of the Royal Horticultural Society's Gardens, Wisley.

Many factors go towards the production of a full crop of fruit in an apple, pear, plum or cherry orchard, some of them within the power of the owner to control, some outside his control. Among the former the choice of varieties and their arrangement in the orchard are important.

The need for careful selection of good market varieties of fruits for planting instead of investing in an interesting collection is being more and more recognised, but the planting of large blocks of only one variety may defeat the ends aimed at. Painstaking investigations carried out in this country and abroad during the past twenty years have established the fact beyond a doubt that one of the important factors in the production of full crops of fruit is the placing of the pollen from one variety of fruit upon the stigmas of another, and this can only be done efficiently when varieties of the same kind of fruit are interplanted.

If the flower of any one of the fruits mentioned is examined it will be found to possess two or three rings of threads just within the petals, topped by knobs containing yellow dust. These organs are the stamens and the dust is the pollen. In the middle of the flower are other thread-like structures leading down to the future fruit; one only in the plum and the cherry, and a group of five in the apple and the pear. These central structures are the styles, and each is tipped by a rough stigma, which at a certain stage is sticky.

Unless pollen reaches the stigma while it is sticky no fruit will be produced. If suitable pollen reaches it then, a series of changes will be commenced, which eventually result in the formation of seeds and fruits. Suitable pollen means pollen from the flowers of the same kind of fruit. Plums require plum pollen, apples require apple pollen, and so on.

It would be a simple matter for this to be achieved, for it is usually easy for pollen to pass from the stamens to the stigmas in the same flower, but various complications arise and it is comparatively rare to find pollen in these fruits effective in causing the production of fruit by the flower of which it formed a part.

The investigations to which reference has been made have had for their object the discovery of how far the pollen would cause fruit to form in (1) the same flower; (2) other flowers of the same variety on the same or other trees; (3) flowers or other varieties of the same kind of fruit.

It has been found that in the vast majority of cases a full crop is produced only when pollen comes from a variety different from that which bears the fruit. In the variety of apple Royal Jubilee, for instance, not one of the many hundreds of attempts to induce the formation of fruits by placing Royal Jubilee pollen on the ripe stigmas of the flowers has been successful. In other words, the apple Royal Jubilee is sterile to its own pollen. Experiments with that excellent apple Cox's Orange Pippin carried out in the same way have shown that Cox's Orange Pippin pollen is effective on the flowers of Cox's Orange Pippin only once in many hundred times. For all practical purposes this variety also is self sterile. Experiments with other varieties of apples have shown that many are similarly self sterile to their own pollen, or set but few fruits when they have that alone available. A few varieties, such as Duchess of Oldenburg and Rev. Wilks, are able to set full crops with their own pollen alone. These, however, are exceptions, and many that are capable of setting a fair proportion of their flowers with pollen of the same variety set a far higher proportion with pollen from flowers of another variety. It is a safe rule to work upon, therefore, that varieties of fruit need pollen of another variety to set a full crop.

The facts established for apples have proved to be true also for pears, plums and cherries, although there is probably a greater proportion of the varieties of plums and cherries that are entirely self sterile than there are of apples. These discoveries provided an explanation for the observation occasionally made that the trees on the outside of a large block of one variety of apple set fruit well, while those inside the block set none or scarcely any. Pollen

from some other variety could reach the outer trees, but only pollen of the same variety could reach the inner ones.

Having established this fact it became important to know how the pollen was carried and what varieties were the most effective in supplying pollen.

Wind is often looked upon as the agent for carrying pollen from one flower to another, and so it is in *some plants, but not in these fruit trees.* In all of them the pollen clings together and experiments show that it is not likely to be carried even a few yards by the wind in such a way as to reach stigmas of neighbouring flowers. The sole effective agents are insects. Many different kinds of insects visit the blossoms of fruit trees, and all of those that fly are likely to play their part in carrying pollen from flower to flower, but some are in the habit of visiting flowers systematically, and these are the most effective agents. Hive bees are always busy on fine days when apples are in bloom, sand bees and others work earlier and later and in less genial weather as well, and are an enormous aid in carrying pollen. Second only to these bees are some of the large two winged flies, especially the hover flies.

Except with hive bees, little perhaps can be done to encourage the visits of these insects or to increase their numbers, but something may be done to preserve them from damage by arranging the spraying campaign so as to avoid the use of poisonous sprays while the flowers are in bloom, and the orchard planting may be arranged so as to aid their work and make it easy for the pollen of one variety of tree to be carried to the flowers of another variety (of the same kind).

Space will not permit a detailed account of the very large number of experiments that have been made during the past twenty years, particularly in the Gardens of the Royal Horticultural Society at Wisley with apples, pears, and plums, and at the John Innes Horticultural Institution at Merton with apples, plums and cherries, and the crossings made by Mr. C. H. Hooper and others with the object of discovering which variety is best for pollinating any other variety of the same kind. The general conclusions only can be given.

The first important conclusion arrived at is that while in very few varieties is the whole of the pollen good (*i.e.*, capable of growing under suitable conditions and causing fruit to be produced), in no variety does it entirely fail, and no variety is to be rejected because of impotence in its pollen. This conclusion has been arrived at not by working with pollen from one place, where the conditions may have been particularly favourable to its development, but after a consideration of the structure and behaviour of

pollen obtained from many different localities, and so as to represent the behaviour of the pollen of a variety over the greater part of the country. Where, for example, 70 per cent. of the pollen of a variety like Ribston Pippin is fertile in one part of the country, about the same percentage may be expected to be fertile in another.

The second important conclusion is that the pollen of any variety of apple or pear is equally effective in bringing about the production of fruit in any other variety of apple or pear respectively. This is generally true also with plums and cherries, but there are exceptions as will be seen later.

If all varieties of apple flowered at the same time it would be a simple matter to plant an orchard so that cross pollination might be brought about. It is no uncommon thing, however, to see one variety completely over before another variety has a flower open. Although two varieties would cross pollinate one another if they flowered at the same time, so long as visiting insects were sufficiently abundant, under these circumstances they are obviously of no use to one another. Only varieties whose flowering time overlaps can provide the pollen that each requires to be brought to it. So long as the flowering time overlaps it does not matter what the varieties are, and this is fortunate, inasmuch as it gives the grower a wide choice, so that he may select within a very little the varieties that best suit his own markets, and need not introdue varieties that are of small value to him.

The need for knowledge as to which varieties flowered together led to the making of lists of order of flowering in many fruit-growing districts, and the keeping of records over a period of years. Several of these lists have been published and examination of them shows that no matter in what part of the country, or indeed of the world, the variety may be in, it maintains the same order of opening its flowers as compared with other varieties. Golden Spire, for instance, is always among the first to flower, and Royal Jubilee and Crawley Beauty among the last everywhere every year. A shorter time may separate these extremes in some seasons, but they always maintain their relative positions of early and late, no matter what their position and what the climate. Similarly, Worcester Pearmain and Cox's Orange Pippin always flower at about the same time as one another in any year and everywhere. This consistent behaviour makes it possible to draw up lists of varieties that may be planted together to provide one another with pollen, with confidence that time, labour and money will not be wasted and the work will not need to be done afresh.

Very full lists of varieties of apples and pears showing their flowering time have been published in the Journal of the Royal Horticultural Society, and the following short lists show some of the common commercial varieties:—*Apples*: Golden Spire, Bismarck, Cox's Orange, Allington, Worcester Pearmain, James Grieve, Lane's Prince Albert, Bramley's Seedling, Newton Wonder, Royal Jubilee; *Pears*: Conference Souvenir du Congrés, Durondeau, Beurré Clairgeau, Louise Bonne of Jersey, Williams Bon Chrêtien, Doyenné du Comice, and Pitmaston Duchess. Each of these varieties overlaps in its flowering time the varieties that follow and precede it in the list, and any of the pairs so made may be planted near each other with the certainty that efficient pollinizers will be available.

The flowering period covered by plums and cherries is on the whole very short, and practically any two commercial varieties will serve to provide each other with pollen, except those mentioned below as incompatible.

When an orchard is being laid out not more than four rows of one variety should be planted in sequence. Then should come a row or two (up to four) of another variety flowering much about the same time, and so on. Where large blocks are already planted and it is desired to provide suitable varieties to supply pollen, then trees here and there should be top grafted in the same proportion with a variety that flowers at the same time.

The fact that at times two varieties will not cross-fertilize one another has been mentioned. This is known to be the case only in plums and cherries. It is useless to plant together for the purpose of cross pollinating, the plums Coe's Golden Drop, Jefferson and Coe's Violet. President and Late Orange also fail to fertilize each other. Among cherries there are more which prove mutually incompatible, such as, Early Rivers, Bedford Prolific, Black Tartarian, and Knight's Early Black, which are all inter-sterile. Bigarreau de Schreken and Bigarreau Frogmore are an incompatible pair, as also are Bigarreau Napoleon and Emperor Francis.

PROGRESS IN HORTICULTURE DURING THE LAST FIFTY YEARS.

By W. Watson, A.L.S.,

Late Curator, Royal Gardens, Kew.

Probably more good is to be got out of a forecast of what the present may lead to than out of retrospection. Hope is encouraged by the one, whereas regret is largely engendered by the other. But the Editor, Mr. Newsham, has suggested that I should say something about changes that have taken place in horticulture during the last fifty years, and the choice of a subject was with him.

Some years ago Mr. Reginald Cory produced, with the aid of experts, *The Horticultural Record.* It gave a full report of the Royal International Horticultural Exhibition held at Chelsea in 1912, with numerous coloured illustrations of some of the exhibits, together with a series of chapters which dealt with the progress made in British horticulture since the first International Horticultural Exhibition, held in 1866. These chapters were as follows:—

Rock Gardens and Garden Making, by Reginald Farrer.
The Rose, by H. R. Darlington.
Trees and Shrubs, by W. J. Bean.
Sweet Peas, by W. Cuthbertson.
Tropical Garden Plants, by William Watson.
Orchids, by James O'Brien.
Carnations, by Charles H. Curtis.
Ferns, by C. L. Druery.
Fruit, by E. A. Bunyard.
Vegetables, by G. F. Tinley.

The retrospect, therefore, covered most of the ground, and was thoroughly done. Mr. Farrer, in one of his best efforts with the pen, glorified the ideal rock garden, but ridiculed the attempts of what he termed amateurs, and recommended the garden craft of the orientals. Fifty years ago there were very few rock gardens of note, now there are hundreds; in fact, a rock garden has come to be looked upon as a necessary and important feature in all good English gardens.

The rose has for centuries been greatly favoured by gardeners. Fifty years ago the hybrid perpetuals were the reigning favourites, teas, hybrid Chinas and Bourbons also finding a place. These were

all displaced by the hybrid teas, a race which has all the best qualities of the rose and the very valuable one of flowering throughout the summer. Permetiana hybrids and Ramblers are more recent additions. The perfect rose has yet to be bred, but great improvements have been made during the last twenty years or so in colours and in constitution especially. Judged by a commercial standard, certainly the rose stands first in importance, as nursery men and market growers could testify.

Hardy trees and shrubs have greatly increased in popularity, thanks largely to introductions from distant countries, particularly China and Japan. It takes several decades thoroughly to test a new tree or shrub, and many of the recent introductions, from China especially, will require such a test before their qualities as garden plants can be ascertained. Some have been condemned already, but there are many that promise to be useful, particularly among Rhododendrons. Lilacs and Clematis also are proving worthy, and there are a few Berberis that have come to stay. Mention must be made of the revival of topiary trees and shrubs which are increasing steadily in favour, although the taste is decidedly un-English, and is not likely to become a permanent feature in our gardens.

The Sweet Pea has sprung into favour with remarkable rapidity. Mr. Cuthbertson dates this rise from 1880, when Thomas Laxton and Henry Eckford brought out improved varieties, among them Countess Spencer, which was the progenitor of the best of the modern Sweet Peas.

Carnations have a somewhat similar history to that of Sweet Peas. Before the advent of the perpetual flowered race, made chiefly in America about 30 years ago, the border carnations were supreme, but the perpetual or winter flowering sorts, grown chiefly in greenhouses, have outrivalled them, and they now rank next to roses as decorative flowers.

Tropical plants, save a few palms, have quite gone out of fashion. They had their day during last century, when magnificent collections were grown in the gardens of the wealthy. The same is true of greenhouse plants, such as Cape Heaths and New Holland plants, which have gradually dropped out in favour of easily grown though tender herbaceous plants and even annuals.

Orchids are the one exception, as they are still in favour, the only change being in the kinds that are grown. Formerly they were all collected and imported from the countries where they grow wild, but now they are bred in this country and the hybrids and seedlings thus obtained are preferred. The most marked success has been

with the genera Odontoglossum, Cypripedium, Cattleya and Cymbidium.

Fruit continues on an even keel. The market has been spoilt in recent years by foreign and colonial competitors. Still, as Mr. Bunyard observed in 1912, "it is well with fruit culture in this country." This is equally true with respect to vegetables. The use of glass houses and frames for forcing certain crops has largely increased, with the result that supplies in winter and spring are greater.

The productions of horticultural art are mainly fruits, plants and flowers that are either useful or ornamental. The former are chiefly fruit and vegetables for use as food; the latter are more or less luxuries which at a push could be dispensed with. This is to some extent also true with regard to such fruit as glass-house grapes and peaches and such vegetables as asparagus and artichokes, though it is difficult to draw a line between the truly needful and the superfluous. Commercial gardening aims at the production in quantity of easily grown crops and it will be in this department that horticulture is most likely to make rapid progress in the next fifty years. The home grown, like the home made must give way to the factory product. The gardeners' methods are more productive than the farmers', and to get the best results the one requires to be grafted on to the other. If the land becomes nationalised there will be none to spare for big private parks and gardens. Of course the love of gardening would remain but it would be more personal and the big expensive gardens which have been a feature of "the stately homes of England" would be things of the past. The farmer, the gardener and the forester would monopolise the land.

The economic position of professional gardeners stands practically where it did 50 years ago. Nurserymen, seedsmen, florists and market growers experience the ups and downs of traders generally. Fashions and tastes change with the result that some of the great nursery firms are no more, but the majority have held their position by moving with the times. During the war gardeners' wages moved upwards together with those of agricultural workers, and they have moved down again since. Taking the cost of living into account the wages of gardeners are about the same as they were fifty years ago. There has been a shortening of working hours as in the case of most workers. An effort was made about 20 years ago to form an association or union of professional gardeners but it gradually petered out and "individual bargaining" between employer and employed still prevails. The result of this state of matters is that intelligent youths

are not attracted to horticulture, though they are sometimes forced into it by cimcumstances, or because there is a prospect of a good job. I have always felt that horticulture as an industry is of national importance and that its workers ought to be strong enough to follow the examples of other industries by forming a union that would look after the interests of trained gardeners.

DRY TREATMENT FOR SMUT DISEASES OF CEREALS.

BY KATHLEEN SAMPSON, M.SC., AND D. W. DAVIES, B.SC.,

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The possibility of using dry chemicals for the control of Bunt of Wheat (*Tilletia tritici*) was first recognised by Darnell Smith, whose data published in 1917 and 1919 (4 and 5) showed the value of dry Copper Carbonate as a fungicide for grain contaminated by Bunt spores. Following this work, Copper Carbonate was tested with good results by Mackie and Briggs in America and Morettini in Italy (19, 20, 23). Since 1921 a large number of tests have been made with chemical dusts for seed-borne diseases and the value of Copper Carbonate as a method of combating Bunt of Wheat has been repeatedly confirmed.

In 1923, the results of some preliminary trials with Copper Carbonate conducted the previous season at Aberystwyth were published by one of the present writers (28) and it was then suggested that the dry treatment possesses several distinct advantages over the wet formalin treatment for Bunt of Wheat, and might possibly be used also to combat certain seed-borne diseases of other cereals.

More extensive trials have been made during the seasons 1923 and 1924, Copper Carbonate again giving excellent control of Bunt of Wheat and promising results in the case of covered smut in Barley. Since the yield data for the 1924 trials are not yet available, the results of both seasons' experiments are held over for a future publication. In the present paper, an attempt is made to survey briefly the already extensive literature which has accumulated on the subject of dry treatment for smut diseases of cereals during the last seven years.

1. The use of dry Copper Carbonate to control Bunt of Wheat.

Darnell Smith and most later investigators have employed Copper Carbonate at the rate of 2 ozs. per bushel of grain. Morettini, testing the efficacy of Copper Carbonate applied at different rates, found 2 ozs. practically as effective as twice or even four times this amount (23). Heald and Smith obtained perfect control with Copper Carbonate at the rate of 2 ozs. per bushel in 1922, and in the following year the use of ½ oz. and 1oz. gave satisfactory results, but perfect control was only given when the dust was used at the rate of 3 ozs. per bushel, and they recommend this amount for autumn seeded grain (12). Mackie and Briggs, after an extensive series of experiments, have shown that different samples of Copper Carbonate vary widely in regard to chemical and physical properties, and that the efficiency of such samples depends to some extent on the density, size of the particles, and percentage Copper contained by the powder. On the basis of their experiments, a standard Copper Carbonate is suggested (21).

The dust is applied when small lots only are to be dealt with by shaking dust and grain in a small container, such as a glass bulb (23). The present writers also obtained efficient covering of the grain by shaking the powder through a fine sieve over a heap of grain which was thoroughly raked during the operation (28). During the last few years, special dusting machines designed for dealing with large bulks of grain have been described in publications by Heald and Smith (12), Stakman and Lambert (29), Mackie and Briggs (21), Melchers and Walker (22). The use of a machine not only secures an even coating of the grain but also minimises the amount of dust inhaled by the operator. This is essential when grain is to be treated on a farm scale.

Since 1917, the Copper Carbonate treatment for Bunt of Wheat has been tested in Australia (4, 5, 6); Italy (23, 24, 25); U.S.A. (3, 11, 12, 13, 14, 18, 19, 20, 21, 22, 27, 29); Canada (9, 10); Great Britain (28); South Africa (26); and Denmark (3*a*, 8)[1]; and the results indicate that invariably a great reduction of disease has followed the treatment, and in some cases absolute control has been given. Heald and Smith, using heavily contaminated seed, obtained only 0.97 per cent. Bunted heads in the Copper Carbonated treated

[1] The writers have so far failed to meet with papers dealing with the Copper Carbonate treatment of Cereals in Germany. Professor Kern, Director of the Royal Hungarian Plant-physiological and Phytopathological Institute in Budapest, refers to the successful use of Copper Carbonate against Bunt of Wheat at the Biologische Reichsanstalt in Berlin, but states that the results have not been published (*Weiner Landwirtschaftliche Zeitung,* 74 *Jahrgang.* No. 69/70, page 289, 1924.

plots as against 40.57 per cent. in the control (12). Hume and Evans (14) obtained complete control with Copper Carbonate when the check plots contained 90 per cent. Bunt. Lambert and Bailey (18) obtained complete control of Bunt with Copper Carbonate, while with Formaldehyde the disease was reduced from 18.5 per cent. to 1.4 per cent. With Fraser and Simmonds, on the other hand, Formaldehyde gave perfect control (but retarded germination), while Copper Carbonate reduced the disease to under 1 per cent. It is evident that on the whole, Copper Carbonate is equal to Formaldehyde in its capacity for reducing the amount of Bunt, but it has certain marked advantages over that chemical in other respects. Thus, there is no record in the current literature of Copper Carbonate causing any injury to the grain, even when treated for long periods of time before sowing (19, 12, 13). Heald and Smith found the germination of Copper Carbonate treated seed higher than the non-treated sample after 8 months storage (12). Formalin, on the other hand, is well known to damage the grain, especially if the grain has been at all injured by thrashing, or if it be stored after treatment (1, 2, 15); but no injury appears to follow the use of a weak Formalin solution (1.480), which Salmon and Wormald have shown to give satisfactory control of Bunt.

Grain treated with Formaldehyde is, moreover, liable to re-infection from contaminated sacks, unless special precautions are taken, but such a danger appears to be almost negligible in the case of grain treated with Copper Carbonate (14, 12). In certain districts of America, soil is an important source of infection in the case of autumn sown wheat. Heald, Zundel and Boyle have shown that in such cases Copper Carbonate gives better protection than Formaldehyde, but is less effective than a Copper Sulphate dip (13).[2]

Investigators with Copper Carbonate have remarked on the great improvement in germination (14, 12, 13, 24), and the increased vigour of growth (13) shown by the treated lots over the control. In most cases it is evident that by the "Control" is meant grain contaminated with Bunt and not treated with a fungicide. It is, therefore, not clear whether the increased vigour of growth observed in the treated lots be due to the stimulating effect of Copper Carbonate on the one hand or to the retarding influence of Bunt in the control lots. Morettini has made experiments to test this point by

[2] In experiments conducted at Lyngby, 1921-23 (34), designed to compare various fungicides in regard to their value when grain is re-contaminated after treatment, Copper Carbonate proved to be considerably more effective than Formalin, Copper Sulphate solution, Uspulun, Germisan Tillantin, Anticorvol, Fusariol or Sublimate.

studying the effect of Copper Carbonate on the growth of seedlings obtained from a Bunt free sample. Using three different varieties of wheat, Morettini obtained 2-3 per cent. better germination from the seed treated with Copper Carbonate 12 days before sowing and a higher final yield. He suggests that the increased yield is chiefly due to the toxic action of the copper dust on moulds or bacteria which attack the grain in the soil, but recognises the possibility of the Copper Carbonate compounds exerting a stimulating effect on the growth of the seedling (24). Experiments to test this point further are in progress at Aberystwyth. Up to the present no stimulating effect has been observed in cases where the seed wheat was sterilised before treatment with a copper dust. Further experiments are necessary before the marked increase in yield which almost invariably follows the Copper Carbonate treatment of a Bunt contaminated sample can be fully analysed.

2. The use of Copper Carbonate to control seed-borne diseases other than Bunt of Wheat.

The success of the copper dust treatment for Bunt of Wheat naturally suggested its use for the Smuts of Oats (*Ustilago avenae* and *U. levis*) and Covered Smut of Barley (*U. hordei*) and other diseases known to be due to infection in the seedling stage by spores carried on the seed.

Excellent control, in one case a 70 per cent. reduction of disease, has been given in the case of hull-less oats contaminated with Loose and Covered Smut, a result which is of particular value since the hull-less varieties are known to be invariably severely injured by the Formalin treatment (3, 13, 7, 29). Results with hulled oats are less uniform—Stakman and Lambert obtained complete control with the variety Victory and good results with Banner, but other workers with the Oat Smut find that Formaldehyde gives better results than Copper Carbonate in the case of hulled varieties.

In the case of Barley, Stakman and Lambert (29) and Tisdale and his fellow workers (32) found that Copper Carbonate reduced but did not satisfactorily control the Covered Smut (*U. hordei*), and the latter authors conclude that for this disease dust treatment is, on the whole, not satisfactory. Tisdale suggests that the spores which cause infection in the case of Covered Smut of Barley are those carried between the hulls and the kernel (31). If this be so, it is not to be expected that in this case a dust treatment will give perfect control. In addition to Cereal Smut Diseases, Copper Carbonate has given promising results with *Ustilago Agropyri*, which causes

a Smut of the Western Rye Grass (10) and with the Sorghum Kernel Smut (*Sphacelotheca sorghi*) (16).

3. Experiments with diluted Copper Carbonate and other chemical dusts.

In 1920 Mackie and Briggs obtained perfect control of Bunt by dusting the grain with a mixture consisting of equal parts of Copper Sulphate (? *anhydrous*) and Calcium Carbonate, the mixture being applied at the same rate as for Copper Carbonate. Since that date, various experiments have been made to discover the cheapest and most effective chemicals suitable for the dust treatment. Fraser and Simmonds tested the effect of diluting Copper Carbonate with a number of different substances, such as infusorial earth—talc, hydrated lime, and others—but came to the conclusion that Copper Carbonate alone gave the best control of Bunt. Good results were, however, given by a mixture of dehydrated Copper Sulphate and Lime made up to contain 15 per cent. metallic copper (9).

Kelsall (17) tested, for the control of Smut in Liberty Oats, a hull-less variety, a number of different compounds, including dehydrated Copper Sulphate and Copper Carbonate, the oxide, sulphide, arsenate, and arsenite of Copper, and the dehydrated sulphates of Aluminium, Nickel and Cobalt. Although Smut was reduced by other chemicals, Kelsall concludes that Copper Carbonate, Copper Sulphide, and dehydrated Copper Sulphate are the most promising materials.* The same worker supports the conclusion of Fraser and Simmonds that the efficiency of Copper Carbonate is impaired by diluting it with other substances. Mackie and Briggs have also arrived at this conclusion (21).

Coons, working with Bunt of Wheat, reports that Copper Carbonate gave slightly better results than a cheaper mixture consisting of dehydrated Copper Sulphate and Chalk, while a proprietory compound called "Corona," containing only 17-18 per cent. metallic copper, gave practically as good results as pure Copper Carbonate containing over 50 per cent. metallic copper. A similar result was obtained by Heald (25).

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* In connection with the use of dry chemicals for treatment of Smut diseases, reference should also be made to the use of Sulphur, which has been tested by a few writers. Mackie and Briggs (21) using Flowers of Sulphur at rates varying from ¼—25 lb. per 100 lb. seed wheat, found that the Bunt was reduced, but not perfectly controlled. Fraser and Simmonds, working with Bunt of Wheat, and Kelsall, with Smut of Hull-less Oats, also report a considerable reduction in diseases following the use of Sulphur. The latter author obtained slightly better results when inoculated Sulphur was used. Sulphur has the advantage of being a cheaper material than Copper Carbonate and is deemed by the authors worthy of further trial.

It is evident from the literature that no definite statement can be made at present as to the minimum per cent. Copper a dust must contain in order to give effective control of Bunt, since the efficiency of a particular dust must depend also, to a great extent, on its capacity to cover the grain. Mackie and Briggs, on the results of extensive experiments, have suggested a certain standard in regard to the chemical composition, and physical properties, of Copper Carbonate used for Smut control, but it is important that further trials be made in this country in order to discover the cheapest form of Copper Carbonate available for the British farmer which is capable of giving effective control of Bunt of Wheat. Experiments on these lines were started at the Welsh Plant Breeding Station by the present writers in the spring of 1924, and will be continued in the coming season.†

The writers gratefully acknowledge the valuable help given by Mr. E. I. Robson, Ministry of Agriculture and Fisheries, in connection with Danish and German literature.

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† In a previous paper, a high figure (6d.) was given by one of the present writers as the cost of treating a bushel of wheat with Copper Carbonate. It is evident from more recent enquiries that cheaper samples are available, which should give satisfactory control of the disease, and there is reason to suppose that in future the actual cost of the chemical will not be a serious factor in preventing the wide adoption of this method of control.

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[1] This list is not complete for all references in current literature to the copper dust method of treating grain, but includes all the more important papers to which the writers had access.

EXPERIMENTS WITH "FINGER AND TOE" DISEASE OF SWEDES;

WITH A NOTE ON LOSS CAUSED BY RABBITS.

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During the last four years the writer has carried out trials with a view to controlling the very serious losses caused by Finger and Toe of swedes in North Wales. It has been shown in previous publications [1 and 2] that two varieties are able to resist the attack of the disease to a marked degree, and the present article gives an account of further work undertaken in 1922 to test the conclusions arrived at in earlier trials.

Distribution of Finger and Toe in North Wales.

The following is an outline of the distribution of the disease in North Wales, based upon more than 400 visits to farms, together with much information obtained from farmers and from the writer's colleague, Dr. C. L. Walton.

ANGLESEY. Severe in an area of about forty square miles lying between the Menai Straits and a line drawn through Pentraeth along the eastern side of the Malldraeth Marsh, particularly in the southern

[1] Whitehead, T., Finger and Toe in Swedes and Turnips; *Report, University College, Bangor*, 1921.

[2] Whitehead, T., Varieties of Swedes Resistant to Finger and Toe, *Journal, Ministry of Agriculture*, Vol. XXIX, No. 4, July, 1922.

half, but excluding the sandy soils around Newborough. With the exception of Holyhead Island, where it is severe, the rest of the county is fairly free.

CARNARVONSHIRE. Prevalent throughout the county, where the most extensive losses in North Wales are recorded. The only areas with any claim to relative freedom are the western end of the Lleyn peninsula and the small area lying between Great Orme and the L. M. & S. railway.

DENBIGHSHIRE. Heavy attacks have been recorded from many of the higher localities, such as Llangerniew, Llansannan and Nantglyn; slight attacks only from the neighbourhood of Ruthin and Denbigh, whilst the rest of the Vale of Clwyd seems to be fairly free. Bad attacks occur near Wrexham and Holt.

FLINTSHIRE. Serious attacks have occurred at Rhosemor, Penyfford, Halkyn and in the St. Asaph district.

Although Finger and Toe is more prevalent on the lighter soils (possibly because swedes are more often grown on this type of land) and in the wetter parts of the area, there are many exceptions, and the explanation of its widespread occurrence is more likely to be found in the fact that liming is not generally practised, although most soils are deficient in Calcium Carbonate—even in some overlying limestone.[3]

On the upland farms also the area which can be put under arable crops is usually so small that roots occupy the same ground much too frequently.

Experiments in North Wales in 1922.

In continuation of the experiments of 1920 and 1921, further trials were laid down in a number of centres in 1922 to test the relative powers of resistance to Finger and Toe displayed by certain varieties. The extremely dry conditions which existed at sowing time caused a complete failure of the swede crop in many districts, including several centres at which trials were laid down. At the College Farm, Aber, and at Tyddyn Hen, Clynnog, however, the seeds germinated well, and, as the autumn was a very wet one, heavy infection of the crops resulted and useful data were obtained.

Method of Examination and Stating Results.

As in previous years the crop was examined immediately upon lifting and before the roots were cleaned. Roots which showed no

[3] Robinson, G. W., Studies on the palaeozoic Soils of North Wales, *Journal of Agricultural Science*, Vol. VIII, Part III, 1917.

signs of disease or those from which the disease would be removed on cleaning were classed as sound, all others being regarded as badly attacked. The intensity of attack was obtained by determining the percentage of the badly attacked roots in each case.

(*a*) College Farm, Aber.

The plot selected for the trial had carried swedes in 1920, and was known to be fairly badly contaminated with the Finger and Toe organism. The plot sloped gently down to the North and the soil varied from a medium to a heavy loam in fairly good tilth.

Two rows each of five varieties of swede were sown in triplicate. series one being sown on May 18th and the rest on June 14th. Notwithstanding the dry weather, all the seed, with the exception of about 60 yards of the Danish variety, 4, germinated well, as did also all the seed in the other two series. In the two latter series yellow turnip seed was mixed with Model swede and sown in the same drills to compare their relative susceptibility to Finger and Toe.

The plan of the plots and the results obtained at this centre are set out in Table 1, which shows that the whole plot was heavily infected. The infection became progressively heavier from the higher ground in the South to the low-lying land in the North, until it reached a maximum in the extreme North-Eastern part, which was water-logged during the greater part of the autumn. It is probable that, with the exception of the use of contaminated manure, the disease is spread mostly by the movement of drainage water carrying with it the spores of the organism. This view is supported by the result of experiments at Bangor, in which pots of sterilised soil have become contaminated by standing in water which has drained through pots containing contaminated soil.

In Table 1 the figures in each case represent the percentage of roots badly attacked in two rows of 29 yards in length. Since the varieties were grown in triplicate and every root in the plot—some 22,000 in all—was separately examined, the figures probably give the relative susceptibility of the different varieties to Finger and Toe with a reasonable degree of accuracy.

(*b*) Tyddyn Hen, Clynnog (Mr. W. Roberts). At this centre, in South West Carnarvonshire, the trial was laid down on land which had not carried swedes or other Cruciferous crop for eight years.

The variety, Lord Derby, was sown as an ordinary farm crop on May 18th, and the experimental plot was sown alongside them on June 6th; two rows each of yellow turnip, Welsh Tankard swede, and Danish variety, 25, being sown alternately. At lifting time two belts were marked across the plot, and 200 roots of each variety were examined in each series, as at the College Farm.

TABLE I.
RESULTS AT THE COLLEGE FARM, ABER.

Variety.	*No. Sulphate of Ammonia.*	*1 cwt. Sulphate of Ammonia.*	*2 cwt. Sulphate of Ammonia.*	*No. Sulphate of Ammonia.*	*1 cwt. Sulphate of Ammonia.*	*2 cwt. Sulphate of Ammonia.*	*No. Sulphate of Ammonia.*	*Average percentage attack per row.*	*Roots destroyed by Rabbits.*
Magnum Bonum ..	28%	38.6%	32.5%	51.6%	52.7%	25.7%	35.4%	37.8%	—
Danish Variety, 25	5.5%	3.8%	0.9%	3.7%	6.1%	5.0%	1.0%	3.7%	—
Viking	13.0%	25.0%	17.8%	45.8%	38.8%	33.3%	24.8%	28.3%	—
Danish Variety, 4 ..	8.3%	8.7%	—	—	13.6%	13.8%	14.6%	11.8%	—
Model	27.6%	16.4%	12.5%	34.8%	48.8%	50.5%	54.1%	34.9%	—
Magnum Bonum ..	31.4%	14.1%	21.1%	19.7%	40.3%	23.1%	39.4%	27.0%	—
Danish Variety, 25 .	6.4%	3.7%	5.5%	8.8%	10.8%	9.6%	3.3%	6.9%	—
Viking	25.0%	24.0%	46.4%	64.8%	50.0%	39.6%	50.6%	42.9%	—
Danish Variety, 4 ..	3.6% (38) 23.0% eaten	2.2% (58) 25.7% eaten	7.9% (43) 20.1% eaten	5.3% (118) 52.6% eaten	21.2% (38) 17.5% eaten	15.9% (88) 43.3% eaten	27.2% (55) 27.7% eaten	11.9%	29.9%
Model	17.0%	7.7%	15.3%	13.3%	44.1%	33.1%	54.9%	26.5%	—
and Yellow Turnip.....	4.8%	3.0%	2.2%	6.6%	27.6%	10.8%	36.3%	13.0%	—
Magnum Bonum ...	12.3%	12.1%	6.0%	6.6%	58.1%	34.4%	55.0% (5) 2.3% eaten	26.3%	0.3%
Danish Variety, 25 .	0.6%	2.3%	1.8% (5) 1.8% eaten	3.2% (36) 11.7% eaten	9.1% (5) 1.8% eaten	15.2% (4) 1.2% eaten	19.6% (9) 3.9% eaten	7.4%	2.9%
Viking	26.6%	60.2%	44.8%	37.5% (1) 0.4% eaten	63.0%	64.4%	69.8%	52.3%	0.06%
Danish Variety, 4	6.3% (12) 6.3% eaten	21.1% (13) 5.0% eaten	18.0% (46) 16.9% eaten	7.9% (76) 28.9% eaten	38.5% (16) 6.4% eaten	40.8% (53) 19.4% eaten	42.7% (31) 14.0% eaten	25.0%	13.8%
Model	33.0%	23.7%	29.1%	29.4%	48.5%	72.7%	59.0%	42.2%	—
and Yellow Turnip	7.7%	11.3%	14.4%	10.6%	12.3%	39.1%	42.5%	19.7%	—

Hedge. ——————> N

The results are as follows:—Yellow Turnip, 5 per cent. and 12 per cent. badly attacked; Welsh Tankard swede, 25.5 per cent., 23 per cent. and 24 per cent.; Danish variety, 25, 2 per cent., 3 per cent. and 3 per cent. The farm crop of Lord Derby had been carted from the field before an examination could be made, but a count made in the yard showed that 31 per cent. had been badly infected —probably an under estimate, as a number of the worst roots were left in the field.

Discussion of Results at the two Centres.

The results at both centres show the high degree of resistance exhibited by the Danish varieties. This is brought out still more by averaging the results obtained with each variety. At the College Farm these are as follows:—Magnum Bonum, 30.3 per cent. badly attacked; Danish variety, 25, 6.0 per cent.; Viking, 41.1 per cent.; Danish variety, 4, 16.2 per cent.; Model, 34.3 per cent.; and Yellow Turnip, 16.3 per cent.

At the second centre the averages were:—Lord Derby, 31 per cent.; Welsh Tankard Swede, 24.1 per cent.; Yellow Turnip, 8.5 per cent.; and Danish variety, 25, 2.7 per cent.

It is well known that turnips do not usually suffer so severely from the disease as do swedes, but it has not been clear whether this was due to real resistance to Finger and Toe or merely because turnips do not usually occupy the land as long as swedes, and therefore have less chance of contracting the disease. The present experiments definitely establish the real resistance exhibited by yellow turnips to the disease.

Effect of Soil Treatment on the Disease.

It will be seen from Table 1 that the plot at the College Farm received cross dressings of Sulphate of Ammonia, each dressing being applied in strips thirty-one yards wide across the rows. In addition the whole plot received farm yard manure at the rate of 12 tons per acre, together with 6 cwt. of 40 per cent. Slag, and 3 cwt. of 30 per cent. Superphosphate. The controls received no Sulphate of Ammonia.

It appears from the results that under the wet conditions of 1922 the full intensity of attack was produced by the normal manuring of the swede crop and that further heavy application of nitrogenous manure were without effect on the amount of disease developing.

Characters of the Resistant Varieties.

The two resistant Danish swedes were produced by Mr. C. I. Christensen of the Danish Experiment Station at Herning by selection from the very susceptible old Danish variety, Bangholm Pajberg; a fact which might well engage the attention of British seedsmen.

Whilst under Danish conditions variety 4 shows greater resistance than variety 25, the reverse is found to be the case in North Wales. The former variety is on the market and can be obtained from the Danish firm, Danske Landhofereningers Froforsyning, of Roskilde, Denmark, under the name "Studsgaard Bangholm." It is understood also that the seed is now to be obtained from a few British seedsmen.

The Danish variety, 25, used in all the writer's trials has been obtained through the courtesy of Mr. Christensen, from the Herning Experiment Station. It may well be that the consistent superiority of this variety is due, less to the different conditions found in North Wales and Denmark, than to the extreme care exercised by the breeder in keeping the strain free from cross fertilisation or accidental mixing with less resistant strains.

Growth Characters.

The Danish varieties grow more slowly and produce a rather smaller root than most of the British varieties tested.. Variety 25 has a somewhat variable colour, purple tops, bronze and green tops occurring in the proportion of 7:5:3 in an actual count, but no relation can be traced between colour of root and resistance to Finger and Toe. The tap-root is usually single and thin so that the roots are easily lifted.

Cropping Power.

The cropping power was determined by sowing twenty rows, each 219 yards long, with alternate double drills of Magnum Bonum and Danish variety, 25. The plot was on land free from Finger and Toe, and amongst other swedes, so that any disease or marginal effect was eliminated. The result is given in Table 2, and, whilst no claim is made to mathematical accuracy, it seems safe to conclude that the yield from the Danish variety was on the average some 1½ tons less per acre than Magnum Bonum. The weighings were made by Mr. E. J. Roberts, Assistant Lecturer in Agriculture in this College.

TABLE 2.

Comparison of Yields from Magnum Bonum and Danish Variety, 25.

Variety.	No. Rows	Weight of Roots in 2 rows. Cwt.	Qrs.	Lbs.	Weight per acre. Roots. Tons	Cwt.	Qrs.	Dry matter. Tons	Cwt.	Qrs.	Lbs.
Magnum Bonum	2	18	2	14	13	19	1	1	4	1	0
Danish, 25	2	16	3	0	12	11	1	1	6	2	14
Magnum Bonum	2	21	0	0	15	15	0	1	7	2	22
Danish, 25	2	19	3	0	14	5	1	1	10	0	25
Magnum Bonum	2	21	1	0	15	18	3	1	8	0	0
Danish, 25	2	19	0	0	14	5	0	1	10	0	25
Magnum Bonum	2	22	0	0	16	0	0	1	8	0	0
Danish, 25	2	19	0	0	14	5	0	1	10	0	25
Magnum Bonum	2	20	1	0	15	3	3	1	6	2	22

Feeding Value.

The feeding value of a number of the varieties under trial was determined in each case by an analysis of twenty roots by Mr. W. McLean, Lecturer in Agricultural Chemistry at this College. The results are set out in Table 3. It is recognised that the number used in the analysis was small, but, confirming as they do the results obtained in 1921, it is not unfair to assume that the Danish varieties possess both a higher percentage of dry matter and of sugar than the other varieties tested. When due regard is paid to the dry matter content it will be seen from Table 2 that the higher cropping power of Magnum Bonum is wholly illusionary since Danish variety 25 produced over 2 cwt. more dry matter per acre than Magnum Bonum, the average figures being: Magnum Bonum, 1 ton 6 cwt. 3 qr.; Danish 25, 1 ton 9 cwt. 1 qr.

Feeding value is usually regarded as varying with the dry matter content so that the Danish varieties probably have a distinctly higher feeding value also—a character of no small importance to the farmer.

TABLE 3.

Composition of Roots of different Varieties.

Variety.	Dry Matter	Total Sugars in Root	Sugar in Juice. Reducing Sugar	Cane Sugar
Magnum Bonum	8.8 per cent.	5.47 per cent.	5.35 per cent.	0.31 per cent.
Danish, 25	10.6 per cent.	5.86 per cent.	5.8 per cent.	0.29 per cent.
Danish, 4	11.1 per cent.	6.25 per cent.	6.2 per cent.	0.29 per cent.
Yellow Turnip	8.5 per cent.	3.32 per cent.	3.3 per cent.	0.15 per cent.

Keeping Qualities.

Finally, it should be pointed out that experiments carried out in 1921 and previously published in detail,[2] have shown that the Danish varieties are likely to keep better in storage than many varieties; for example, after eight weeks' storage 61 roots of the variety Lord Derby and 58 of Magnum Bonum had rotted so completely as to be unfit to feed to stock, whereas from a larger number of roots originally clamped each of the Danish varieties had only four discarded for the same reason.

Conclusions.

It appears to be definitely established that two varieties of swede produced by selection from an extremely susceptible parent possess powers of resistance to Finger and Toe to a marked degree, and, in addition keep better and have a higher feeding value than other varieties tested.

It is also clear that yellow turnips are able to resist the disease better than many swedes.

Resistance to Finger and Toe is not directly related either to the total dry matter or to the amount of sugar present in the root and the factor determining resistance must be searched for elsewhere; this is evident from a comparison of the resistance and chemical composition of yellow turnips and either of the Danish varieties.

There is little doubt that the use of a resistant variety is advisable on land badly contaminated with Finger and Toe. Even on land free from this disease there is considerable evidence that the increased dry matter content, feeding value and keeping qualities, of these resistant-swedes will more than counter-balance the reduced yield of roots per acre.

The following note suggests, however, that additional precautions to keep down rabbits will be necessary where these swedes are grown, unless the rabbit rather than the farmer is to benefit by their cultivation.

Note on the Loss caused by Rabbits.

In November of 1922 it was noticed that considerable damage was being caused in the Finger and Toe Experimental plot at the College Farm by rabbits and between 50 and 60 were secured from the hedge (cf Table I) by a professional catcher. The results of this infestation were examined in some detail by the writer and certain conclusions drawn appear to be of sufficient interest to place on record.

It was observed that although very many roots in all the varieties had been nibbled, in some rows the roots were eaten level with the ground. After the crop had been lifted, the roots which had been

so completely eaten that they could not be "pulled" were dug up and counted. Table I gives both the number destroyed (in brackets) and the percentage of the crop this number represents in each thirty yard strip of the plot.

It will be seen that the rabbits displayed a most epicurean taste, for whilst Magnum Bonum, Viking and Model swedes and yellow turnips were almost entirely untouched 744 roots of the Danish varieties were destroyed. Of these, 59 belonged to variety 25 and 685 to variety 4; reference to Table 3 will indicate that this selective feeding was in all probability due to the high sugar content of the Danish swedes.

Seven hundred and forty-four of the Danish varieties weigh on an average about 9 cwt. so that as a rough approximation it can be said that 50 rabbits were responsible for the loss of a good half-load of the swede crop.

The remains of the eaten roots were examined for Finger and Toe but although only a very few were badly affected with the disease no significance is probably to be attached to this fact.

SOME EXPERIMENTS ON POTATO LEAF-ROLL TRANSMISSION IN WALES.

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It is now generally believed that the production of seed potatoes is largely—and possibly wholly—a question of keeping the stocks free from infection by the so-called virus diseases, of which leaf-roll appears to be one of the most serious in this country.

A considerable amount of evidence is available to show that various insects which feed on potato foliage are able to transmit these diseases from diseased to healthy plants, and most workers on virus problems agree that Aphides or "greenfly" (of which the common greenfly on roses may be taken as a type) are mainly responsible for this spread of disease.

According to this view, the value of Scotch seed depends upon the fact that potato greenfly is either absent or appears late in the season in the good seed-potato growing districts of Scotland, so that little transmission of virus diseases takes place. When the seed is planted under the warmer conditions of the south, where greenfly is often abundant on the potatoes, the diseases spread rapidly and, on

growing a second year, a large percentage of the crop may be diseased. In the case of leaf-roll or "curl" the yield may be reduced by at least half and the grower is compelled to purchase a fresh stock of Scotch seed.

At one of the meetings of the Welsh Agricultural Education Conference held at Cardiff in December, 1922, the writer suggested that experiments laid down in different parts of Wales might lead to the discovery of localities where virus diseases spread relatively slowly and where other conditions for good potato culture existed; trials could then be instituted to test the possibility of developing these districts for the production of seed potatoes. With the help of the county staffs the writer was enabled to lay down an experiment for this purpose in four counties in Wales in 1923, some of the more important results of which are now briefly described.

Plan of the County Trials in 1923.

Sixty-three tubers of the variety Arran Comrade were sent to each centre; of these 60 were from the same consignment of seed from Banff in Scotland, and three were from a crop of badly rolled plants grown at Aber in 1922. The trial was laid down according to the following plan by the county staffs at the Llysfasi Farm Institute, Denbighshire; Madryn Castle Farm School, Carnarvonshire; The Union Gardens, Builth Wells, for Brecon and Radnor; and at Lisvane, near Cardiff, Glamorgan.

1	0	0	0	0	0	0	0	0	0	9
10	0	0	0	0	0	0	0	0	0	18
19	0	0	0	0	0	0	0	0	0	27
28	0	0	0	●	●	●	0	0	0	36
37	0	0	0	0	0	0	0	0	0	45
46	0	0	0	0	0	0	0	0	0	54
55	0	0	0	0	0	0	0	0	0	63

The plants were numbered as in the diagram, Nos. 31, 32 and 33 being the infectors. Previous work in North Wales had shown that during the season in which disease is passing from diseased to healthy plants the latter show no symptoms at all or, if apparently present, they are quite unreliable; this opinion was fully borne out by the notes taken as to the appearance of the foliage at the different centres in 1923. At each centre observations were also made as to the degree of insect infestation on the trial plot. The disease passes the winter in the tuber, so that by planting the tubers produced by each plant the following year it is possible to tell with certainty which of the "parent" plants were infected in the previous year. At each centre the produce from each plant was lifted separately

and despatched to the College Farm, Aber, where it was boxed at once. On March 20—22, 1924, the entire crop from each plant was planted in separate compact plots, so that it was possible to trace the whole progeny from any 1923 plant.

The plots were kept under close observation during the summer of 1924 and in June and August detailed notes were taken of each *plant* as to the occurrence of leaf-roll.

Observations on the Plots at Aber in 1924.

The most casual observation was sufficient to show striking differences in the amount of leaf-roll in the plots, for whilst the Madryn plot was almost completely healthy, the crop from Builth Wells was stunted and badly rolled; the other two centres occupying an intermediate position. These results were fully substantiated by the detailed notes and are strikingly evident when diagrams are constructed from the available data. Considerations of space prevent full details being given, but the following summary clearly shows the difference in spread at the four centres:—

LLYSFASI, DENBIGHSHIRE.—27 plants out of the originally healthy 60 were infected in 1923=45 per cent. Of the tubers produced by these 27 plants 52.5 per cent. showed leaf-roll symptoms when grown at Aber in 1924.

MADRYN, CARNARVONSHIRE.—9 plants out of the 60 were infected in 1923=15 per cent. An average of 31.5 per cent. of the tubers produced by these 9 plants developed leaf-roll in 1924 at Aber.

BUILTH WELLS, FOR BRECON AND RADNOR.—45 plants out of the 60 were infected in 1923=75 per cent. An average of 81 per cent. of the tubers produced by these 45 plants had leaf-roll in 1924 at Aber.

LISVANE, GLAMORGAN.—31 plants out of the 60 were infected in 1923=52 per cent. An average of 55.6 per cent. of the tubers produced by these 31 plants developed leaf-roll in 1924 at Aber.

A similar trial to test the spread of leaf-roll and mosaic was laid down at the College Farm, Aber, in 1923 with six varieties. Although the results are not strictly comparable with those at the other four centres, since only 45 tubers were used—of which the centre three were infectors—it is interesting to note that in Arran Comrade 13 out of 41 healthy plants became infected=31.6 per cent.; an average of 39.6 per cent. of the tubers produced by these 13 showing leaf-roll in 1924. It is probable that if the same number of tubers had been planted as at the other four centres many of the outermost plants

would have remained healthy and a lower result than 31.6 per cent. would have been obtained—though it would obviously have been higher than the 15 per cent. infection recorded at Madryn.

Discussion of Results.

On the basis of the above results the centres can be divided into two groups, as follows:—

1. Relatively little spread of leaf-roll—Madryn and Aber in Carnarvonshire.
2. Considerable spread at Llysfasi, Denbighshire; Lisvane, Glamorgan; and Builth Wells, Brecon.

It will be noticed that in centres where the greatest spread occurred there was also a much higher percentage of the tubers produced by these newly infected plants which developed leaf-roll on planting in 1924. It is possible that this indicates the length of time during which infection of the healthy plants occurred in 1923, there being sufficient time in some centres to enable the disease to penetrate to most of the tubers whilst in other centres most tubers escaped infection. This rather obvious explanation, however, should be accepted with caution, since we do not as yet know whether the susceptibility to leaf-roll in the same variety is affected by the locality or conditions under which it is grown.

In 1923 Aphides were scarce or absent at Madryn, scarce at Aber, fairly numerous at Llysfasi and Builth Wells, whilst a rather heavy infestation was observed at Lisvane in July and none at all in August. The trial was laid down under sheltered garden conditions at Llysfasi and Builth Wells; under rather sheltered field conditions at Lisvane, and in exposed fields at Madryn and Aber.

It seems fairly safe to conclude that the difference in the amount of spread at the various centres was due to the different degrees of shelter, which permitted Aphides to breed in greater numbers in the more sheltered conditions. This is borne out by the results of a survey still in progress in North Wales by Dr. C. L. Walton and the writer.

It is perhaps scarcely necessary to add that the results do not enable any comparison to be made of the relative suitability of the four *counties* for seed potato growing; the most that can be deduced from the trial is that leaf-roll spread so slowly at Madryn in 1923—even though infected plants were deliberately introduced into the plot—that seed obtained from the plot would be reasonably healthy when grown in 1924, whereas seed from the Union Gardens at Builth Wells would not have given more than half a normal crop.

It is worth noting that Madryn is in the same locality in which several varieties have been grown without change of seed for periods varying from 15 to 40 years, without infection with virus diseases or any serious loss—if any—of cropping power.

The results appear to be of sufficient practical importance in determining the conditions under which seed-potatoes may possibly be grown, as to justify further trials of this kind in other centres in 1925.

It remains only to thank Mr. J. Roberts, of Llysfasi Farm Institute; Mr. E. Jones, of Madryn Farm School; Mr. J. G. Watson, Horticultural Instructor for Brecon and Radnor; and Mr. G. H. Copley, Horticultural Instructor for Glamorgan; for their care in carrying out the trials. Also Dr. C. L. Walton, who made the insect counts at Aber, Llysfasi, and Madryn; and Mr. H. W. Thompson, who similarly estimated the degree of insect infestation at Lisvane; Mr. Watson reported on the infestation at Builth Wells. Finally, acknowledgment is due to Mr. A. P. Jones and Mr. O. R. Morris, Research Assistants at this College, for their help in carrying out the trials at Aber in 1924.

A NEW DISEASE OF CULTIVATED CAMPANULAS DUE TO SCLEROTINIA SCLEROTIORUM (MASSEE).

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Description and Distribution of the Disease.

In July, 1923, cultivated Campanulas were reported as dying off in a district near Cardiff. The stems were split open and numerous black bodies, varying in size from that of a pin head to that of a kidney bean, and varying in shape from round to irregular kidney shape, were found about the region of the ground level. When the plants were moistened, very abundant white mould developed like a felt covering the stem and formed more sclerotia. Some of these black bodies were afterwards cultivated on artificial media and the white mould and the sclerotia were again developed and showed every resemblance to those of the fungus known as Sclerotinia sclerotiorum, which has been recorded as often causing serious damage to numerous other plants, for instance, the stalk disease of

potatoes described by Pethybridge from Ireland. The fungus also occurs on beans, marrow, cucumber, tomato, sunflower, artichoke, and others, and during storage on carrot, turnip, mangold, etc. Mr. A. D. Cotton wrote that, until then, it had not been recorded on Campanula.

In the beginning of June, 1924, the writer was consulted about a "mildew" occurring on Campanulas in another garden from the same district as the above. The variety most attacked in this case was Campanula persicifolia var. alba, but other varieties were also attacked. In this case it was observed at an earlier stage and the feature of the attack was the discolouration, with development of mould and consequent rotting and falling over, of the stem. The green colour disappeared, leaving the stem a grayish-white for about an inch or two, starting at the axil of a leaf and then working very rapidly upwards and gradually downwards, covering the stem with a felt-like mass of mycelium in which were embedded small harder bodies of various sizes, at first grayish on the outside but later becoming black and resembling the bodies obtained the previous season. The ground, which was a meadow last season, was trenched over deeply in the autumn and "colliery" (horse) manure applied. It is generally held that this disease is favoured by the use of green stable manure.

About a fortnight later, the disease was noticed in a garden at Usk in Monmouthshire on the variety of Campanula known as "Cup-and-Saucer." but did not affect more than a few plants, the weather at the time being drier. It is probable that the disease is more widely spread than is indicated above, but that its intensity depends on the weather conditions.

Life History of the Fungus.

The black bodies, or sclerotia as they are called, either fall to the ground or remain in the dead stems over the winter. In spring, stalks about 2 inches long grow out of the sclerotia and appear just above the ground, supporting small disc-like heads, from which numerous spores escape. The spores are carried by the wind on to growing plants and generally settle in the axils of the leaves where very often moisture remains longer. There the spores germinate, and the mycelium enters the tissue of the plants, producing inside and on the surface abundant white mycelium, parts of which become more compact, forming the sclerotia, which eventually become hard and black. Rainy weather causes the rapid spread of the disease, and the past season was, therefore, particularly favourable. This Sclerotinia sclerotiorum is closely related to S.trifoli-

orum, which attacks clovers and similar leguminous plants, causing "clover sickness."

Methods of Control.

The following measures of control are suggested:—

1. The removal and burning of all diseased stems. This was followed with good results this year when done promptly.
2. Plants liable to attack should not be grown on ground which has borne infected plants previously or which is adjoining. The soil should be sterilized or the top two inches removed and replaced by fresh soil mixed with quicklime.
3. As indicated above, fresh manure may carry the disease, and it is therefore necessary, if any is used, to ascertain that it is not contaminated, and it should not be used excessively.
4. The causal organism can attack a large number of other plants and weeds, which may spread the disease to new ground.

THE INSECT ENEMIES OF FARM CROPS.

By J. C. F. Fryer, M.A.,

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In the first place it must be admitted that the application of entomological knowledge to the control of insect pests on the farm is a difficult problem which cannot be approached from the point of view of one who is familiar only with methods of destroying fruit pests and who in consequence regards spraying machines and insecticides as the economic entomologist's chief stock-in-trade. Much as it is to be regretted, the direct attack on the insect pests of the farm by chemical means is seldom possible, and as this fact restricts the entomologist from using one of the chief weapons in his armoury, it may be of interest to explore certain of the directions still left open to him.

First in importance in this connection is a recognition of the relations which the economic conditions of the farming industry bear to the losses caused by insect pests. A hypothetical instance will render this clear. Suppose that on a certain farm the potential yield of oats be 40 bushels per acre, but that one year in every three, owing to attacks by leatherjackets, the yield be reduced to 20 bushels. Then in such a case the maximum sum which could be spent, either on remedial measures during the year of attack or on preventive measures spread over the whole period, would be something less than the value of 20 bushels of oats. This maximum

expenditure could only be justified if the preventive or remedial measures were completely and invariably successful, which, of course, is not always the case, and if the other hazards to which the crop is subject were inconsiderable. The net result then is that even in a bad case (for the loss of 50 per cent of the crop every third year would clearly be bad) there would not be more than 30s.—£2 10s. per acre—according to the price of oats and the reliability of the methods employed—to be spent on insect control. Thus only 2 cwt. per acre of a chemical costing £1 a cwt., or 4 cwts. at 10s. per cwt., could be applied. Of course, the statistics of insect attack cannot ordinarily be reduced to such simple terms as these, but if it be assumed that an annual average loss of about 16 per cent. is decidedly a high estimate, and if further the value of the average farm crop be remembered, it will at once appear that the money available for pest control is small, and indeed inadequate for the introduction of processes involving the use of expensive chemicals and special apparatus.

So long, therefore, as the value of farm produce bears its present relation to the cost of materials and labour, the efforts of the entomologist are perforce confined to methods involving little or no expenditure on the part of the farmer. Such methods must in the main consist either in appropriate modification of existing farm practice or in the growing of varieties of crop resistant to the attacks of insect pests. Within the space of this article it is impossible to deal in detail with attempts to control along either of these lines any special pest, and discussion must therefore be limited to certain general considerations.

First, some reference may be made to the insects of grassland, not because any definite action with regard to them is indicated, but because Wales is a country with a large area of pasture and hill grazing and therefore insects which attack grasses have a special interest. To all appearance grassland of all types suffers remarkably little from insect attack, but it is nevertheless supporting an insect fauna more numerous and more extensive than any other farm crop. The species comprising this fauna fluctuate considerably in numbers—in one year perhaps Grass Moths (*Crambidae*) will be prominent and in another Crane Flies (*Tipulidae*), but with certain exceptions there would seem to be little variation in the growth of grass to correspond with the predominance or scarcity of any particular species. It would, therefore, seem that grassland has so adjusted itself to the insect burden which it carries that growth on account of insect pests shows little variation. It would not do, however, to assume from this that no loss is being caused. The

reverse must be the case, for the grass plant has first to feed whatever insects are present before any surplus is available for beast or hay, but this loss—whether it is great or small—is not seen owing to the fact that it is fairly constant from year to year and so is invisible to the observer, whose standard is merely comparative. Such a position—where stable conditions have been reached between a crop (or association of plants) and its enemies—is not very favourable to the intervention of the entomologist, but where the interests in grassland are considerable and research on the subject is being actively prosecuted, the entomological aspect is at least worth consideration. That it has possibilities is shewn by any of the exceptional cases where damage to grassland is both obvious and great. In South Wales, for instance, epidemics of Antler Moth caterpillars (*Chareas graminis*) occur now and again, with the temporary destruction of all the hill grazing affected. It is found, however, that damage is practically confined to areas where Mat Grass (*Nardus stricta*) and similar moorland grasses are predominant, and that the caterpillars do not thrive on the better meadow grasses. Probably the same attachment to definite species occurs in the cases of pests which do less damage and are more constantly present, and there appears therefore no reason why seeds mixtures for grassland should not be so adjusted as to render the resulting turf unfavourable to the more common species of grassland pest, without reducing its value for other purposes. There is also room for much observational work on the influence on grassland insects of such cultural measures as the burning over of hill pastures and of such involuntary treatment as the flooding of low-lying meadows and grazing.

Grassland, however,—from the entomological aspect—is still largely an unexplored field in comparison with the other crops of the farm. In regard to the latter, the lines along which success may be sought fall usually into one of the following divisions.

I. *The cultural treatment is directed to encourage the efforts which a crop always makes to resist and so "grow away" from the insect pest.* The usually quoted instance of this type of treatment is the application of a top dressing of nitrogenous manure, with a view to promoting rapid growth. In theory this is perfectly sound, but in practice it often fails owing to the application being made too late, the plant being too greatly damaged to make use of the manure by the time it has actually become available to the roots. Unless, therefore, an attack can be

discerned at an early stage, nitrogenous top dressings are better regarded as preventive than as remedial measures.

Another instance of the same class of treatment consists in the encouragement of the tendency of most cereals to tiller. When the first shoot of a cereal is destroyed the plant may be entirely killed, but if not buds at the base at once start into growth so as to repair the injury. If the plant can be induced to tiller early—as, for instance, by rolling—the risks of the destruction of the entire plant by wireworm, leather jacket, etc., will be greatly reduced.

II. *An attempt is made to prevent the crop from reaching a stage highly susceptible to insect attack at a time when the pest to be feared is in great abundance.* The best known instance of this is in the case of the Carrot Fly when it is found that carrots sown early—say, in March—are much more heavily infested by Carrot Fly larvae than those sown later—say, in May—owing to the fact that the first brood of the flies has partially died off by the time the May sown carrots are above ground. Another familiar instance is the early sowing of oats to avoid the Frit Fly—with the object of having the plants past the most susceptible stage before the time when the Frit Flies appear.

III. *By appropriate organisation an endeavour is made to render the farm as unsuitable as possible to the continued existence of insects.* The ordinary farm rotation is the simplest illustration of this, for the insects which only attack clover, for instance, are forced to go elsewhere or die when the clover is broken up and oats are sown. In furtherance of the same object it is clearly desirable to force the insects from the clover to travel as far as possible before finding food, and therefore in the instance just quoted it should be arranged that the next field to be sown with clover should be one as distant as possible from the field to be broken up. An extension of the same line of reasoning is found in the cases where a susceptible crop is replaced in the rotation by one known to be resistant to the particular pest to be feared—e.g., the sowing of beans instead of oats on land known to be infested with wireworms. In connection with attempts such as these, weeds have an obvious importance, for they may enable the insect to tide over a period when the cropping of the farm is unfavourable; most cereal pests, for instance, will feed on couch grass, and most turnip pests on charlock.

Apart from the organisation of the cropping on such lines as the above, it is sometimes possible to discourage the presence of insect pests on the farm by reducing the amount of winter shelter available

for them. The examination in winter of any heap of dead weeds, litter, or other rubbish left near a turnip field, will usually disclose a quite astounding number of Turnip Flea Beetles, and it is obvious that if the heap be burnt these pests would be destroyed. Conditions for the destruction of insects in winter in Wales are not perhaps as favourable as they are in parts of England, owing to the differences in winter climate and the amount of shelter available, but opportunities in one direction or another must undoubtedly occur and a settled policy of seizing upon them will not be wasted. Specially is this the case in areas largely devoted to market gardens and allotments.

The notes given above indicate some of the directions in which the losses due to insect attack may be mitigated by cultural measures—the other directions in which success may ultimately be obtained is the production of resistant varieties, a subject requiring the joint efforts of the entomologist and the plant breeder. There are almost certainly big advances to be made in this field, but it has to be recognised that the problem is a difficult one owing to the fact that most insect pests are not very restricted in their tastes. In consequence a considerable alteration in the character of a plant may not render it resistant to the attacks of the pests. On the other hand, there is in most insect pests a definite periodicity, adults, larvae, pupae and eggs only being found at certain seasons—which may be quite brief. Equally, a crop is usually only susceptible to attack during certain well-defined stages of growth. It therefore may be possible. by breeding and selection, to change the rates of growth of a crop so as to prevent its susceptible stages from coinciding with the times when the insects are most prevalent.

Considerations of space prevent any reference to a still further potential means of controlling farm insects—the utilisation of natural parasites. It is hoped, however, that enough has been said to show that although the application of entomology to agriculture is handicapped by economic considerations, yet there are directions in which it should be capable of rendering very valuable service. These directions are such as will lead to a general and steady improvement, but they cannot be expected to give spectacular results. Moreover, entomological research of the kind alluded to involves not merely the activities of the entomologist, but also of the farmer, the agricultural organiser, the chemist, the plant breeder, and indeed almost everyone interested in either agricultural education or research. Wales is, however, most fortunate in being able to call upon the services of a most efficient team of agricultural workers, and the future of agricultural entomology in the country can with safety be left in their hands.

NOTES ON WARBLE FLIES IN NORTH WALES.

By C. L. Walton, Ph.D., M.Sc.,

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Distribution, Abundance, etc.

Two species of Warble Flies, *Hypoderma lineatum* and *H. bovis*, are abundant in Great Britain, and are a source of serious loss and annoyance to Cattle breeders. In some districts *lineatum* is the predominant species, in others *bovis*. During the progress of a Survey of the Agricultural Zoology of the Aberystwyth Area during 1913—16, notes were made regarding the distribution and relative abundance of the larvae, and *lineatum* was found to be the usual species; *bovis* being by no means common (1).

Further data have been added regarding the distribution of these pests in North Wales during the period 1920—24, and these are now given, together with the results of some experiments on their control.

As in Mid-Wales, *H. lineatum* is by far the most abundant species. Warburton (2) states that *bovis* only oviposits on hot sunny days, while *lineatum* seems to be much less dependent on sunshine, and this is probably the chief reason for the scarcity of *bovis* in these regions of relatively high rainfall.

The bulk of the data here given have been drawn from the country lying between Llanfairfechan, Bangor, and Lake Ogwen, in Carnarvonshire, and again, from between Menai Bridge and Gaerwen, in Anglesey. These two districts thus include typical lowland (and coast) and mountain farms. A few records were also obtained from the Conway Valley, etc. *H. bovis* occurs on all types of land, but so far has only exceeded 10 per cent. of the Warbles present in the herds examined, in two or three cases. In most instances only one or two animals are infested with *bovis*.

In all, 767 cattle of all ages have been examined in North Wales, yielding a total of 3,083 warbles, giving an average of approximately 4 per animal. Within these totals, however, great variations exist, and these fluctuations are shown in Table I, which is compiled from herds upon which experiments were undertaken.

TABLE I.

	1920			1921			1922			1923			1924		
	Cattle.	*Warbles*	*Average*	*Cattle.*	*Warbles*	*Average*	*Cattle.*	*Warbles*	*Average*	*Cattle.*	*Warbles*	*Average*	*Cattle.*	*Warbles*	*Average*
A. College Farm ..	36	159	4.41	58	103	1.7	57	361	6.3	52	440	9.6	52	7	0.14
B. All Farms	59	194	3.29	as	abo	ve.	106	615	5.8	144	1317	9.14	401	844	2.1

In each case the above figures refer to one count only, and therefore may not show absolutely the whole number present, since some may appear later.

Bishopp (3) states that in the U.S.A. wet springs are always unfavourable to Warbles, having an ill effect on the pupae and on the egg-laying adults. Low infestation follows a cool rainy spring. The following figures bear this out and should be compared with Table I.

TABLE II.
RAINFALL—PENRHYN CASTLE GARDENS.

	1919	1920	1921	1922	1923
April	1.50	3.86	1.83	3.09	2.99
May	1.24	4.18	2.09	.91	3.38
June	2.25	3.92	0.34	1.01	1.29
July	2.59	10.02	2.85	4.02	3.08

It will be seen that there is a distinct correlation between the abundance of Warble larvae and the rainfall of the three spring months of the preceding year; even allowing that the number of cattle included is not high. The spring of 1923 was particularly cold and sunless, and the infestation of 1924 was markedly low.

As regards the distribution of infestation, the mountain herds often give higher counts than those of the lowlands, and there appears to be a relatively higher infestation on the rougher lands than in the more highly farmed districts. Although I cannot support the statement by figures, I am of the opinion that the practice of washing the cattle with various preparations, and the use of tobacco powder, etc. (against Lice), have a decided effect in reducing infestation, since in a number of cases where these measures are in use, counts have been decidedly lower than on neighbouring farms, where such treatment is not practised. Shade and available water also play a part, and appear to reduce, or even prevent, attack in some few instances.

As regards age, undoubtedly the heaviest infestations are among young cattle, although older ones (and even aged cattle in bad years) are by no means immune.

The highest individual counts obtained were 67 and 50 on Anglesey heifers, 2/4/24; and a number of instances of 40 odd on heifers from Llanrwst, Bethesda and elsewhere. The highest numbers recorded for cows are 39, 32, and 27 respectively.

As is well known, *H. lineatum* larvae make their appearance much earlier than do those of *H. bovis,* and leave the cattle to pupate much sooner. It appears that seasonal differences also exist, and in 1923 quite 60 per cent. of *lineatum* larvae had left the cattle by April 24th in several herds then under observation. May, 1922, was exceptionally fine and dry, .91 inches of rain falling on 4 days only at Penrhyn Castle Gardens, and .26 on 11 days at Penrhyn Quarries, Bethesda. Exceptionally early larvae are now and again observed; one 27 m.m. in length being sent from near Bethesda, 11/2/21; while another of 21 m.m. was extracted near Bangor, 27/2/24. Apart from such exceptional cases, the date of first perforation of the hide was watched for in several herds in 1924. Slight swellings could be detected beneath the hide in mid February, but the first actual perforations were not noted until February 19th, while in other herds February 26th was the earliest date. Once perforation takes place, growth is very rapid. During 1923—24 the larvae present on the right and left sides of the majority of cattle examined were noted separately, with the following results

In 1923, out of a total of 1,279 larvae, 744 were situated on the left, and 535 on the right side; in 1924, out of 981 warbles, 562 were on the left, and 419 on the right, giving a preponderance of 352 for the left side, out of a total of 2,260.[1] In 1923, out of 143 cattle of all ages, 88 showed a preponderance on the left side; 35 on the right side; while 20 had the numbers equally placed. In 1924, in 165 cattle, 90 showed an excess on the left; 42 on the right; and 53 were equal.

Warbles are by no means uncommon on horses (4). Few larvae have been received in good preservation, but one was recognisable as *H. lineatum,* and two good examples of *H. bovis* have been identified from near Bethesda, 23/6/20; and Mold, 4/4/24 (see Pillers (5).

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1 Mr. R. F. Montgomerie, B.Sc., M.R.C.V.S., Veterinary Adviser here, offers a suggested explanation of this preponderance. He points out that the deviation of the gullet from the median line locates a considerable proportion of this organ on the left side of the body. Thus a large proportion of the Warble larvae would appear to commence their final migration from a position to the left of the median line.

Control Experiments.

In the "Report of the Entomologist" of the U.S.A. Department of Agriculture for 1921, p. 20, it was stated that 100 per cent. control had been obtained by the use of a mixture of Iodine and Vaseline. An ointment was at once made up and used, but was not successful, and it was subsequently ascertained that the Report should have read Iodoform instead of Iodine, and I have to thank Dr. L. O. Howard and Mr. F. C. Bishopp for details as to formula and application. The latter stated that an ointment of 1 part Iodoform and 5 parts Vaseline applied to the larvae and pressed into the openings made into the hide would effect a kill of at least 95 per cent. In 1923, some experiments of an incomplete character were carried out, 63 cattle being treated twice, giving, however, 84 per cent. control, both on the College Farm, Aber, and in Cheshire (where Mr. G. E. Shaw carried out an experiment at my suggestion). Bishopp recommends 4 treatments.

In 1924, experiments were commenced on February 26th, to thoroughly test the treatment under North Wales conditions, and were continued to 30th May. This involved the personal examination and treatment of 186 cattle on 10 different holdings, and the results are given in Table III.

TABLE III.

Herd.	*A.*	*B.*	*C.*	*D.*	*E.*	*F.*	*G.*	*H.*	*I.*	*J.*	*Total*
No. of Cattle	16	61	13	22	9	10	12	13	11	19	186
No. of Warbles—1st application	49	100	3	21	33	14	2	12	40	71	345
,, 2nd ,,	25	77	9	6	48	7	2	14	40	67	295
,, 3rd ,,	16	31	17	1	24	2	2	8	17	19	137
,, 4th ,,	31	10	21	3	8	1	2	6	31	15	128
,, 5th ,,	16	1	0	0	0	0	0	2	12	18	49
,, 6th ,,	2	0	0	0	0	0	0	0	5	3	10

Note. 6 cows were withdrawn in herd *B.* from various causes and 2 were sold out of *E.* during the experiments.

The Iodoform and soft paraffin ointment used, cost (in experimental quantities) about 1s. per ounce, and is easy to obtain and apply. One ounce will treat from 70 to 100 warbles, and after a little practice I have treated 100 warbles in an hour. In order to gain as much information as possible, 6 applications were made at (roughly) fortnightly intervals. In actual practice four would suffice, the first being not later than mid-March, the others following at intervals of a month, the last being to make certain that no *H. bovis* remain untreated. In 1924, the first larvae of this species were obtained on April 8th. When the experiment was terminated

on May 30th, 10 mature larvae of *H. bovis* remained alive, and were extracted and destroyed. In examining Table III, increases in the number of warbles present will be noted at the 2nd application (in two cases) and in the later applications in several instances. The early ones are due to the fact that *H. lineatum* larvae were still appearing, while the later rises in number are due to larvae of *H. bovis.*

The method of application used was to locate the orifice of the Warble, and to apply the ointment on the index finger of the right hand, taking care to leave the orifice plugged with the remedy. In North Wales, the larvae are known as *Gwerid.*

The experiment shows that the use of Iodoform and Vaseline ointment resulted in an almost complete destruction of the Warbles, and thus confirms the contention of Bishopp, and also that of Howard (6), who considers that the evidence indicates that Hypoderma might be eradicated by concerted action.

In addition to the above, some preliminary experiments were tried, using an ointment of powdered Derris root and soft paraffin (7). Derris is a cheaper substance than Iodoform, and odourless. The results obtained with 91 cattle were most promising, and it is hoped to complete the experiment in 1925.

Farmers in North Wales frequently use very strong salt solutions, which they state kill some numbers of warble larvae, and one claims success with a smear of diluted black treacle applied to the back.

I wish to offer my sincere thanks to the owners of the numerous herds visited, or used for experiment; also to Messrs. Llewelyn Williams, B.Sc., and W. Norman Jones, B.Sc., for assistance on various occasions.

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A TEST OF THE TOBACCO POWDER AND LIME MIXTURE FOR THE DESTRUCTION OF WARBLE MAGGOTS.

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The following is a summary of the results obtained from the application of this treatment to six herds of cattle in Glamorgan and Monmouthshire during the spring of 1924. The results shown below are for *two* dressings only.

The treatment was carried out as recommended in form No. 155/T.A. of the Ministry of Agriculture and Fisheries and by Prof. G. H. Carpenter, using 1½ lbs. of fresh lime, 4 lbs. of tobacco powder, and 1 gallon of water.

The tobacco and lime were allowed to soak in the water for 24 hours, then the liquid was strained off through a fine mesh gauze and applied to the backs of "warbled" cattle by means of a sponge. This was done carefully, so as to ensure that some of the liquid penetrated the hide by means of the breathing hole and came into contact with the grub. Two applications in each case were given at an interval of 2 or 3 days, and almost all the dressings were applied during March and April; the liquid used was made up fresh for each application.

In the case of five of the herds, the cattle dressed were milking cows, which were, therefore, dressed in the stalls. These presented no difficulty in the application of the treatment or in counting the number of warbles present. In the sixth, the cattle were yearlings, which were driven into a barn for dressing. This made the application rather awkward and rendered the estimation of numbers of warbles present difficult. In this case, therefore, independent estimations were made by two persons, which were found to agree very closely.

The results obtained from the six herds were:—

No. of cattle dressed	95
No. of warbles found to be present	631
No. of warbles killed by the treatment	470
Percentage killed by application	74.5 per cent.

This result is lower than would have been obtained by dressing tied up cattle only, as the warble mortality on the loose animals

was only about 65 per cent., which lower result is probably due to the difficulty of treating the animals.

On two of the farms, the warble mortality on tied up animals after two dressings was about 90 per cent., and it was found that another application about three weeks after the first was sufficient to kill all the warbles. In practice it would probably be found possible to give several dressings between the beginning of March and the middle of May, as the amount of time taken up in the application of the dressing is quite small. Twenty or more cattle can be treated by one man in an hour.

It seems clear that the method employed, if persisted in, would give highly satisfactory results, and if generally employed would reduce to a very large extent the annual loss caused to cattle owners by this pest.

FORESTRY IN WALES.

By Fraser Story,

Forestry Commission, London.

Wales, with practically everything in its favour as a timber-producing country, is nearly destitute of woods and likely to remain so unless there is an awakening to the benefits accruing from afforestation.

Up to the time of the appointment of a Royal Commission on coast erosion and afforestation, whose report was issued in 1909, not much had been done for economic forestry in Wales. That report, which was the first to recommend State afforestation on a large scale, led directly to the inclusion of forestry in the Development Commission's schemes, and to the appointment of forest advisers who exercised a marked influence upon private forestry prior to 1914. At that time timbered estates in nearly every county in Wales were being regularly visited by arrangement with the owners, tree planting was proceeding satisfactorily, a beginning had been made with the preparation of working plans for forest management on several estates, and a few experimental plantations had been formed to test the comparative merits of various species suitable for use in Wales.

Unfortunately, just as the new work in afforestation was establishing itself and extending its scope, war broke out and activities, previously focussed upon the formation of woods, had to be directed to their destruction. In no part of the United Kingdom was the

devastation of woods for the production of timber in war-time more complete than in Wales. Felling operations from 1914—1918 cleared away nearly the whole of the mature stands of larch, pine and spruce. Forest depletion, of course, took place in all parts of Great Britain and the consequences were so serious that, had the war continued for another year, little or no coniferous timber would have been left in the country and we should have been placed in an extremely difficult position.

Recognition of the public danger of having insufficient home supplies of timber in times of emergency led to the appointment of the Forestry Reconstruction Committee, under the chairmanship of Mr. F. D. Acland, and the drawing up of recommendations which have had far-reaching effects. The principal result of this Committee's labours was the passing of the Forestry Act of 1919, which provided for the appointment of a Forestry Commission, or in other words, the establishment of a State Forest Service.

Basing their plans on the recommendations of the Acland Report, the Forestry Commissioners propose to plant 150,000 acres of softwoods in the first 10 years, and aim at the afforestation of at least 1,770,000 acres in 40 years. An expenditure of £3,500,000 in the first 10 years is allowed under the Act, and Wales, with a Forestry Consultative Committee of its own, is constituted an executive unit. During the first four years of its existence the Forestry Commission acquired in Great Britain 121,000 acres of plantable land and planted some 27,700 acres. Up to the present approximately 12,000 acres of plantable land have been secured for tree planting in Wales. The rate of acquisition is now increasing rapidly, but there are difficulties in the way of afforestation in Wales which public opinion by backing up the action of the Commissioners can do much to remove.

Only 4 per cent of the Principality is afforested, whereas about 25 per cent. consists of mountain and heathland, much of which is more suitable for timber production than anything else. The area under timber is estimated to be only 184,000 acres, while the mountain and heathland below the 1,500 ft. contour is returned as no less than 1,000,000 acres. In order to bring the timber area of Wales up to the average of other European countries it would require the afforestation of 1,400,000 acres. It is therefore evident that to equal our neighbours, who have given so much attention to forestry, and who find they require all the timber they grow, the whole of the plantable area in Wales would have to be taken in hand. Even the most enthusiastic forester would hesitate before embarking on a scheme of such magnitude. The comparison between our forest area

and that of Continental countries is only made in order to draw attention to the extent of our deficiency.

Wales falls below the normal standard in forest area not because its natural conditions are inferior to those of foreign countries nor because there is any lack of demand for forest products, Great Britain being the largest importer of timber in the world, but chiefly because it is so difficult to make a start and requires the exercise of so much patience to carry the work through effectively.

The character of the Welsh mountains and the climate of Wales are altogether favourable for tree growth; nowhere else in Britain can one find such large continuous stretches of almost ideal afforest-able land. There is probably no district in Europe where such a large volume of timber per acre may be obtained. While it would be quite a mistake to imagine that all the mountains in Wales could suitably be planted with trees, the fact remains that large areas—in the aggregate probably not less than 300,000 acres—producing remarkably little at present, could be profitably utilised for forest cultivation.

Next to financial considerations, which are very serious in the case of private owners afforesting bare land, the great difficulty in the way of afforestation in Wales is that most of the land suitable for tree planting is providing grazing for sheep. It may be argued that the sheep are relatively few in number and that the production of timber would be large; that ten men would be employed where only one finds work at present; that the financial returns from the land would be considerably increased under timber crops; still, the sheep are in possession—in many districts forming an almost invisible occupation of territory—and they are not easily dismissed.

The withdrawal of a moderately sized area from its present use would have scarcely any appreciable effect on the curtailment of food supplies, and there would be no displacement of labour at all. Assuming the ultimate transference from hill pasture of so large an area as 300,000 acres, the loss of meat to the country would amount to less than 2,000 tons annually, whereas the production of timber would be increased by nearly 400,000 tons annually. Viewed broadly, the proper test would seem to be whether much of the mountain land in Wales is reasonably productive in its present state or whether its productivity could be materially improved. The main object should be to get the most we can out of the land. There would appear to be room in the Principality for the prosecution of both agriculture and silviculture, and it should not be impossible to maintain a proper balance between the two.

A promising recent development which may help matters is the sanctioning of a scheme whereby forest workers may be settled on or close to areas afforested and allowed a cottage and a piece of land for cultivation, while devoting most of their time to forestry work. This combination of small holdings with permanent employment in forestry has been a marked success on the Continent and seems to be particularly suitable for adoption in Wales. It is a form of land settlement which will probably appeal to everyone.

As showing how far our country is dependent upon outside sources of supply, it may be stated that in 1922 £28,000,000 worth of softwoods were imported from foreign countries. A striking example of the country's dependence upon foreign timber of a class which could most easily be produced at home is the annual importation of three million tons of pit-props. It should be borne in mind that 90 per cent of Britain's consumption of timber has to be imported and that the world's softwood supplies are rapidly diminishing.

Afforestation on a large scale is doubtless primarily an affair for the State. Owing to the length of time which timber crops require to reach maturity, private enterprise in tree planting is seriously handicapped; on the other hand, the State can afford to wait for deferred returns when these are likely to prove satisfactory, and on national grounds it would appear to be the Government's duty to see that provision is made for future supplies of timber. Furthermore, continuity of management is not easily assured except under State control.

While this is so, it should be borne in mind that it was the private estates of the country that produced most of the timber felled during the war, and over 95 per cent of the afforestable land in Wales is either common land or in the possession of private individuals. One has only to think of the fine woods on estates such as Powis Castle, Cawdor, Penrhyn, Dol-llys, Llandinam, Leighton Hall and Kerry—to mention only a few—to realise how much has been done by private initiative in the past. Great service has been rendered to forestry by the use that has been made by landowners in Wales of conifers introduced from other countries, more especially from North-West America. Not only plantations but also large numbers of estate parks afford ample evidence of the rapid growth of these trees and of their possibilities for use in economic planting. Some of the best timber produced in Europe has been grown on Welsh estates. The scale of operations, however, has not been commensurate with the amount of suitable land available, and it is to this aspect of the subject that one would particularly wish to draw attention.

Some encouragement has recently been given to landowners by means of funds placed at the disposal of the Forestry Commissioners for the relief of unemployment, and advantage has been taken of the scheme in nearly all parts of Wales, several thousand acres having been planted and an almost equal area prepared for planting, by the recipients of these grants, which amount to £3 per acre in cases where wages are paid to men unemployed at the date of their engagement. Much, however, still remains to be done in the extension of afforestation on private and public lands. The large and thriving plantations at Lake Vyrnwy are a splendid example of what may be done in afforestation by corporate bodies.

Since 1904 systematic instruction in forestry has been available at the University College, Bangor. The degree of B.Sc. may there be taken after a residence of three years, and shorter courses are provided for students who, while they do not intend to make forestry their profession, wish to qualify themselves for the management of timbered estates. The more elaborate courses of study include instruction in forest management, valuation, silviculture, forest protection, forest botany, utilisation, surveying, engineering, physics, the chemistry of soils, forest entomology and the economics of forestry. The forestry school at Bangor is exceptionally favoured in its situation, being close to extensive areas of afforestable land and immediately adjacent to a forest nursery, well-managed woods and a wonderfully varied collection of indigenous and exotic trees.

At some distance from Bangor, but available to the students as an experimental area, are the demonstration plots at Chirk. The freehold of the land on which these plots are situated was presented eighteen years ago to the Denbighshire County Council by a private landowner on condition that the area should be placed under the supervision of the forestry authorities at Bangor and devoted to the illustration of practical forestry. The scheme of experiments has been wholly successful and is now yielding results which are of value to foresters not only in Wales but in all parts of the country.

This is perhaps not the proper occasion on which to discuss the species of trees best adapted for afforestation under the varying conditions of soil and climate to be found throughout Wales. Forestry is a highly technical science and the choice of species should only be made after a careful examination of each locality. In cases where planting schemes of any considerable magnitude are contemplated an expert who can visit the ground should certainly be consulted, but to landowners and land-agents, operating on a modest scale, the following remarks may prove helpful.

Among the trees which may be specially recommended for economic planting in Wales are a few whose outstanding merits are not as yet sufficiently recognised. These trees are Douglas fir, Sitka spruce, Corsican pine and Japanese larch. For nearly all positions where the trees will not be exposed to the prevailing winds, and where the altitude is not excessive, Douglas fir will be found to be the most profitable species. In most cases it will yield under these conditions a gross return of about £5 per acre per annum, producing as it does a readily marketable timber of excellent quality, useful in all descriptions of constructional work.

Less sheltered situations, including great masses of Welsh mountain land, may be more safely planted with Sitka spruce, a species easily satisfied in respect of soil and whose requirements in regard to moisture are always likely to be fully satisfied in Wales. Heavy crops of this quick-growing conifer can be produced where larch would not be successful, and for the timber a profitable market is assured. Badly exposed sites and areas near the coast may be planted with Corsican pine, and where there is a ready outlet for pit-props the Japanese larch may be relied upon for the production of a large yield and early financial returns.

Afforestation, if conducted on rational lines, may confidently be expected to prove remunerative, and no better location for its development can be found than among the mountains of Wales. There need be no encroachment upon arable land, and any substitution of forest for poor pasturage will be fully compensated by increased production of a necessary commodity—one for which at present we are almost wholly dependent on foreign countries. Afforestation offers a new source of employment and a new source of wealth, while hundreds of families could ultimately be maintained on industries connected with the products of the forests. From all points of view—national, social and industrial—forestry deserves the hearty support of every section of the community.

ABSTRACTS, REVIEWS, AND BIBLIOGRAPHICAL NOTES.

ANIMAL NUTRITION.

Amino-Acids of Feeds; Quantitative Determination of.

T. S. HAMILTON, W. B. NEVENS and H. S. GRINDLEY. *J. Biol. Chem.*, 1921, 48, 249-272.

Further improvements have been made in the application of Van Slyke's method to the estimation of amino-acids in feeding stuffs.

J.J.G.

Animal Nutrition; Studies in.

V. Changes in the composition of the mature dairy cow during fattening. C. R. MOULTON, P. F. TROWBRIDGE and L. D. HAIGH. *Missouri Agric. Expt. Station Res. Bul.*, 61 (1923).

Tables give the wts. and composition of the various organs and parts of cows. From 40—76 per cent. of the gain of wt. in mature cows is due to fat.

J.J.G.

Chickens; Rearing of on the Intensive System.

I. The vitamin requirements. R. H. A. PLIMMER and J. L. ROSEDALE. *Biochem. J.* (1922) 16, 11—18.

Chickens were successfully reared on a diet of oatmeal and milk provided the 3 vitamins were also present. The chickens are particularly susceptible to an insufficient vitamin B supply.

II. The effect of good protein. *Ibid* 19-22.

Rapid growth results on a diet having an albuminoid ratio of 1:3, and containing "good" proteins, caseinogen and lactalbumin.

III. B—vitamin requirements. Comparison of yeast extract and dried yeast. R. H. A. PLIMMER and J. L. ROSEDALE. *Biochem. J.* (1923) 17,772--786.

The quantity of marmite—a yeast extract—required with various diets for pigeons and chicks are given. If the marmite be put at 100 "cerema"—a cheaper form of yeast ext. than marmite—has a value of 75. dried yeast of 50.

J.J.G.

Cod Liver Oil in the Winter Feeding of Milch Cows.

J. C. DRUMMOND, K. H. COWARD, J. GOLDING, J. MACKINTOSH, and S. S. ZILVA, *J. Agric. Sci.* 1923, 13, 144-152.

Experiments are described on the effect of feeding cod liver oil to cows yielding milk, the butter fat from which was deficient in vitamin A. It was found that the feeding of cod liver oil had no uniform effect on milk yield or fat content, and the effect was in all cases much less than the result of grass feeding. No flavouring of milk or butter was perceptible when the animals received up to 4 oz. of oil per day. Indoor feeding of cows in winter, even where ensilage is used, causes a decrease in vitamin content in the milk compared with summer milk.

J.J.G.

Cod Liver Oil; use of—in the Feeding of Farm Animals.

J. C. Drummond, S. S. Zilva and J. Golding. *J. Agric. Sci.* 1923, 13, 153-162.

A discussion of the nutritive value and market qualities of cod liver oils is given, together with methods and quantities suitable for feeding to cows and pigs. Lower grades of oils should be avoided, and storage in air-tight vessels is necessary to prevent loss of value by oxidation.

J.J.G.

Cod Liver Oil, Linseed Oil and Olive Oil; Influence of—on the assimilation of Calcium and Phosphorus in the Growing Pig.

A. B. Husband, Wm. Godden, and M. B. Richards. *Bio-chem. J.* 1923, 17, 707-719.

The beneficial effect of the oils does not seem to be connected with their content of vitamin A. J.J.G.

Cotton-Seed Meal Poisoning.

J. P. McGowan and A. Crichton. *Bio-Chem. J.*, 1924, 18, 273-282.

A condition resembling the injury which has been attributed to poisoning by cotton seed meal can be induced in pigs by feeding them on substances concerning which there can be no suspicion of toxicity. It is probable that the disease is brought about in young pigs which have already suffered as sucklings to a greater or less degree from iron deficiency on an incomplete diet. Iron in the form of ferric oxide seems to have a specially beneficial effect in preventing development of the symptoms.

J.J.G.

Diet and Light; Influence of on Vitamins of Milk.

Ethel M. Luce. *Bio-Chemical Journal*, 1924, 18, 716-739.

The diet of the cow appeared to be the main fector in determining the growth promoting value of the milk. The anti-rachitic value depends on the diet of the cow, and possibly also on the degree of illumination to which she is exposed. J.J.G.

Dietary Requirements for Reproduction;

I. Nutritive value of milk proteins from the standpoint of reproduction.

II. Existence of a specific vitamin for reproduction.

B. Sure. *J. Biol. Chem.*, 1924, 58, 681-692, 693-709.

Rats fed on a complete artificial diet with milk proteins as a source of nitrogen were found either to be sterile or to be unable to rear their young. No improvement in this respect was obtained after attention had been directed to all the known requirements as regards vitamins, salts, iodine and paricular amino-acids. From these experiments and those of Evans and Bishop (*J. Metabol. Res.*, 1922, I, 319, 335, 1923, 3, 201, 233) the existence is deduced of a hitherto unrecognised "vitamin E" essential for reproduction, and present in Georgia velvet, bean pod meal, polished rice, yellow corn (maize) and rolled oats. J.J.G.

Dry Meal Hoppers for Pigs.

C. C. Reilly. *Journ. Ministry Agric. and Fisheries*, 1922-23, 29, 816-819.

Results of experiment on self feeding of dry meal to pigs. J.J.G.

Egg Production; Food in Relation to.

E. J. Davey. *Journ. Ministry Agric. and Fisheries.* 1922-23, 29. 745-748.

Laying trials extending over three years at the Harper Adams College are summarised. J.J.G.

Ensilage of Oats and Tares; Changes which occur during the

A. Amos and H. E. Woodman. *J. Agric. Sci.* 1922, 12, 337-362.

In the case of green "fruity" silage obtained from the crop cut soon after flowering and ensiled without wilting considerable loss of dry weight occurred, especially where sap drained away.

More than 50 per cent. of the original protein was decomposed into "amides"; much of which may be lost in the drainage. If the crop was dried by wilting or by allowing the plots to mature acid brown silage was obtained. The loss of dry wt. during ensilage was relatively low, and drainage was small. About 30 per cent. of the original protein was transformed into "amides." When the crop was allowed to wilt excessively and afterwards wetted with rain, a tendency to become mouldy was displayed. Some evidence was obtained suggesting the partial break-down of cellulose during ensilage. J.J.G.

Ensilage of a Green Crop; Changes which occur during the.

H. E. Woodman and A. Amos. *J. Agric. Sci.*, 1924. 14. 99-113.

Previous work is extended and confirmed, and the manipulation necessary to produce the two types, "green fruity" and "acid brown" silage is standardised. The chemical changes occurring in the production of these two types of silage are shown to differ considerably. While the losses involved through drainage in the fruity silage are greater, it is superior to the acid brown type in palatability, digestibility and nutritive value. J.J.G.

Fat Soluble Factor; The Relation of the—to Rickets and Growth, in Pigs, II.

J. Goulding, S. S. Zilva, J. C. Drummond, and Katherine Coward. *Biochemical Journal*, 1922, 16, 394-402.

Having been unsuccessful in producing rickets in pigs experimentally by depriving them of vitamin A alone, an attempt was made to ascertain whether a dietetic deprivation of calcium and vitamin A would lead to the production of the disease. In spite of the marked changes effected by the restricted diets, no rickets in the pathological sense of the word was induced. J.J.G.

Fish Meal; Effect Produced upon the Fat of Hogs by Feeding.

J. B. Martin. *J. Assoc. Off. Agric. Chem.*, 1923, 6, 498-501.

The flesh and fat of hogs fed on good quality fish meal had no characteristic smell or taste, although the fat contained small quantities of the glyceride of clupanodonic acid. J.J.G.

Fodder; Preservation of.

I. So-called sweet silage.

G. Wiegner, E. Crasemann, and J. Macasanik. Landw. Vers.—*Stat.*, 1923, 100, 143-268.

Chemical examination and animal feeding experiments with silage prepared in a number of different ways are described and a comparison is made with ordinary hay crops. The digestibility figures for silage were better than those for hay in regard to organic matter, ether extract, N—free extract and calories, but poorer in the case of pure protein.

The starch value of silage was slightly higher than for hay. The yield of foodstuff per hectare was in favour of the hay. On the other hand, the crop for silage can be cut 2-3 weeks earlier than for hay and is less affected by unfavourable weather conditions. J.J.G.

Whey; Production, Composition, and Utilisation of.

R. A. Berry. *J. Agric. Sci.*, 1923, 13, 192-239.

A detailed description of the commercial methods of production in milk and cheese factories and of the present use of whey is given. The possibility of drying surplus whey for distribution is noted. The dried product is valuable as a stock and poultry food. The establishment of a factory for the production of milk sugar and by-products in Scotland is recommended. J.J.G.

Food Essentials.

C. H. Hunt. *Ohio Agric. Expt. Station, Mo. Bull.*, 8, 3-7, 1923.

Goat milk is richer than cow milk in vitamin C. The sources and functions of vitamins A, B, and C are discussed. J.J.G.

Foodstuffs; Relation between the Calorific Values of.

Obtained by combustion and by calculation and nutrition.

J. König and J. Schneiderwirth. Z. Unters. *Nahr. Genussm*, 1921, 42, 3-23.

As a result of a large number of comparative analyses various suggestions are made for the modification and amplification of routine calculations made in nutrition experiments.

Grasses; Nutritive Value of—as shown by their Chemical Composition.

T. W. Fagan and H. T. Jones. Univ. Coll. of Wales, Aberystwyth. Welsh Plant Breeding Station. *Bull.* 3, *Series H*, 85-144.

The results of analytical work carried out on the composition of fifteen different grasses, representative of the chief species and strains under investigation at the Station are given. Generally speaking, the grasses producing the greatest yield gave the greatest weight of nutrients. Of all the grasses experimented with, indigenous Meadow Foxtail and Golden Oat Grass produced pasture of the highest quality. Indigenous types of grasses produced hay slightly superior in composition to that produced by the commercial types. The aftermath differs from hay in having a greater proportion of leaf to stem. Its chemical composition, therefore, more closely resembles that of pasture. The high yielding Cocksfoot grasses have the disadvantage that the hay produced is of a decidedly fibrous nature. The leaf portion of the plant is distinctly more nutritive than the stem and a knowledge of the relative proportions of these parts provides a fair guide to the nutritive value of a pasture at any period of the year. J.J.G.

Home Grown Corn and Potatoes for Live Stock.

T. B. Wood. *Journ. Ministry Agric. and Fisheries*, 29, 780-783, 1922-23.

The relative values of home grown and purchased feeding stuffs are considered. J.J.G.

Home Grown Foods; When should the Farmer Sell.

A. G. Ruston and J. S. Simpson. *Journ. Min. Agric and Fisheries*, 29, 783-788, 1922-23.

The circumstances under which it would pay on the one hand to feed, and on the other to sell home grown foods are discussed.

Lupins and their Utilisation.

C. BRAHM. *Z. angew. Chem..* 1922, 35, 45-48.

A review of the literature concerning the composition of lupins from the point of view of fodder and of the methods of removing the noxious alkaloidal substances. Attention is confined to the white, blue and yellow lupins. J.J.G.

Mangolds; the Food Value of—and the Effects of Deficiency of Vitamin A on Guinea-Pigs.

ELLEN BOOCK and J. TREVAN. *Biochemical Journal,* 1922, 16, 780-791.

Vitamin A and Calcium salts are shown to be deficient in a diet of mangold, bran and oats and water. The protein was also shown to be deficient. An epidemic amongst the guinea-pigs could be entirely controlled by alteration of diet. J.J.G.

Nutrition; the Bearing of Recent Research on Problems of.

D. G. O'BRIEN. *Scot. J. Agric.,* 1921, 4, 140-8 (*Expt. Station Record,* 45, 373).

The importance of vitamins in animal feeding is discussed and a feeding experiment at the West of Scotland Agricultural College is briefly described, in which pigs were fed on a ration of corn, bran and middlings, supplemented by whey. Since the pigs had been on a milk diet prior to the experiment, it is thought that they had an ample reserve of vitamin A and thus derived no benefit from the added vitamins provided by the whey. Later, when the reserve was depleted, growth was promoted by the feeding of more vitamins. J.J.G.

Nutritional Requirements of Baby Chicks.

II. Further study of leg weakness in chickens.

E. B. HART, J. G. HALPIN, and H. STEENBOCK. *J. Biol. Crem.,* 1922, 52, 379-86.

Baby chicks were reared to a weight of 800 g. or more (11 weeks) on a diet of white corn, skimmed milk, NaCl, CaCO3 and cod liver oil, with a litter of shavings. When the cod liver oil was omitted, the animals died in from 4-6 weeks, developing "leg-weakness" and showing a low inorganic P. in the blood serum. J.J.G.

Nutritive Value of Lactalbumin.

T. B. OSBORNE and L. B. MENDEL. *J. Biol. Chem.,* 1924, 59, 339-345.

The results of a number of feeding experiments show that lactalbumin is a protein of comparatively good nutrient quality under dietary conditions, in which the vitamin supply is adequate.

J.J.G.

Palm Kernel; Growth—Promoting Value of the Proteins of the—and the Vitamin Content of Palm-Kernel Meal.

A. J. FINKS, D. B. JONES. *J. Agric. Res.,* 1923, 25, 165-169.

40 per cent. of palm-kernel meal did not furnish sufficient vitamin A. in the diet of rats to prevent Xerophthalmia. The meal used was the residue after oil removal by solvent process, and the results obtained may not apply to the fresh, untreated palm-kernel nut. J.J.G.

Pig Feeding Experiment. (Indoor versus Outdoor Feeding).

By W. G. R. PATERSON, West of Scotland Agricultural College. Reprint from the *Transactions of the Highland and Agricultural Society of Scotland* 1923.

The experiment was conducted to ascertain relative rates of progress made by fattening pigs with a free run as against those confined. The results do not support the outdoor system when rapid fattening is aimed at.

J.J.G.

Pigment of Silage; Nature of.

H. E. WOODMAN. *J. Agric. Sci.*, 1923, 13, 240-242.

The yellowish brown colouring matter of silage possesses all the properties of phaeophylin, its production from chlorophyll being probably due to the carbon di-oxide and organic acids developed during fermentation.

J.J.G.

Poultry Fleshing Investigations.

The utilisation of soy-bean and corn proteins as affected by suitable mineral supplement.

D. C. KENNARD, R. C. HOLDER, and P. S. WHITE. *Am. J. Physiol.*, 1922, 59, 298-309.

For fattening cockerels a mixture of corn meal and soy bean meal supplemented by minerals produced gains only slightly inferior to those produced by corn meal and buttermilk. Without mineral supplement, corn and soy bean meal did not prove a satisfactory ration, the resulting gains being much smaller and consisting largely of fat. J.J.G.

Proteins; The Relative Value of—in Nutrition.

R. H. A. PLIMMER. *J. Soc. Chem. Ind.*, 1921, 40, 227-9R.

A review on the nutritive value of isolated proteins, Work on the proteins of common feeding stuffs is cited. J.J.G.

Protein, Fat and Carbohydrate; Comparative Values of—for the Production of Milk Fat.

E. J. SHEEHY. *Sci. Proc. Royal Dublin Soc.*, 1923, 17, 211-7.

The author concludes from feeding experiments with goats that the milk fat yield of lactating animals can be increased within limits by feeding. If a diet is constituted so as to contain less than a certain quantity of fat, the maximum yield of milk fat will not be returned no matter how liberal the ration is in quantity. Fat in the ration of a lactating animal stimulates the secretion of milk fat. This stimulative action required for max. milk fat production is induced by a comparatively small quantity of fat; fat fed in excess of the requirements for this purpose has no special value apart from replacing carbohydrates. J.J.G.

Protein; A Method of Determining the Biological Value of.

Biological value of proteins at different levels of intake. Supplementary relations among proteins.

H. H. MITCHELL. *J. Biol. Chem.*, 1924, 58, 873-903, 905-922, 923-929.

From experiments on rats the proportion of the food protein which is actually used by the body is determined and expressed as a percentage of the total available protein; it is termed the "biological value" of the protein. The content of digestible protein multiplied by the biological value and divided by 100 gives the net protein value of a food. Results are given for different foods. J.J.G.

Protein Digestion Coefficients; Method of Correcting.

H. E. Woodman. *J. Agric. Sci.*, 1924, 14, 428-433.

Emphasis is laid on the difficulties attaching to any attempt to determine the exact extent to which the protein of a foodstuff is digested by an animal. Reasons are given for retaining the "apparent" digestion coefficients. J.J.G.

Roots versus Silage for Dairy Cows.

A. W. Oldershaw and F. C. Smith. *J. Ministry Agric.*, 1921, 28, 614-21.

Feeding experiments with oat and tare silage and yellow globe mangolds used with dried grains, decorticated cotton-seed meal, chaffed straw and kale showed that 60 lbs. of silage is not equal in milk producing capacity to 60 lbs. of mangolds and 4 lbs. of concentrated foods. The cost of the silage ration in the production of milk, however, was less than that of the root ration. J.J.G.

Silage; Temperature and Other Factors Affecting the Quality of.

A. Amos and G. Williams. *J. Agric. Science*, 1922, 12, 323-336.

From an examination of silage samples prepared under differing conditions, a general classification was worked out. "Sweet" dark brown silage is produced when the temperature rises above 45°—50° C., with a fairly free access of air. It is only produced in a shallow layer near the surface in tower silos. It is pleasant in flavour, but has lost much of its feeding value. Acid light brown silage is obtained in tower silos from moderately mature crops allowed to wilt until the original moisture content is reduced to about 70 per cent. The fermentation temperature is 30°—37° C. Green "fruity" silage is produced in tower silos from crops cut at a period between full flower and when the seeds are half formed, and ensiled directly after cutting. It is palatable and has a high digestibility. The fermentation temperature is 22°—34° C. During ensilage much liquor drains away. Sour ensilage is obtained if immature and succulent crops are used, or if the crop becomes saturated with rain after cutting and before ensiling. Musty silage is reported from a crop of over-ripe wheat containing charlock which was allowed to become too dry before ensiling. J.J.G.

Silage; The Growing of Crops for—and some Experimental Results.

J. P. Drew. Dept. of Agric. and Technical Instruction, University College, Dublin. Reprint from the *Department's Journal*, Vol. XXIII, No. 2.

Methods adopted for the growing of crops for silage are indicated, and the relative costs of growing silage and mangels at the Albert Agricultural College, Glasnevin, are given. Some results of feeding experiments are also given, carried out with the object of comparing silage with mangels. The experimental work is being continued. J.J.G.

Silage for Milk Production: A Comparison with Roots and Hay.

R. G. White, E. J. Roberts. *Journ. Min. Agric. and Fisheries*, 1922-23, 29, 34-37

There is very little difference between the silage and roots-fed cows during the first period of the experiment, but during the second period the results are decidedly in favour of the silage ration. J.J.G.

Silage; Feeding Trials with.

V. C. FISHWICK. *Journ. Min. Agric. and Fisheries*, 1924-5, 31, 50-58.

Results of trials are given showing oat and tare silage to be a satisfactory substitute for roots in the ration of dairy cows. J.J.G.

Silage; Feeding Experiments with.

R. RAE and H. W. GARDNER. *Journ. Min. Agric. and Fisheries*, 1924-5, 31, 261-266.

An experiment is described in which silage plus roots are compared with roots, and another experiment in which silage plus roots are compared with silage. The silage plus roots ration is cheaper than the roots ration, while the silage ration is cheaper than that including roots. J.J.G.

Sodium Hydroxide; Effect of—on the Composition, Digestibility and Feeding Value of Grain Hulls and other Fibrous Material.

J. G. ARCHIBALD. *J. Agric. Res.*, 1924, 27, 245-265.

Feeding experiments with sheep showed that hydrolysis with 1.5 per cent. sodium hydroxide markedly increased the digestibility of the important constituents of oats and barley hulls and doubled the feeding value of oat hulls. The improvement in the digestibility of rice hulls was not sufficient to be of economic importance. J.J.G.

Sunflower Silage.

A. AMOS and H. E. WOODMAN. *J. Agric. Sci.*, 1923, 13, 163-168.

The results of analyses of products obtained by the ensilage of sunflower plants are described. An extremely small loss (5 per cent.) in dry matter during ensilage was found. The change in crude protein in the ensiled sunflower is small, and the decomposition of true protein is considerably less than is the case with oat and tare silage. The digestibility of the protein of sunflower silage is less than that of the protein of oat and tare silage. The palatability of the sunflower silage was fairly satisfactory.

It is suggested that the relatively fibrous nature of the stems might be avoided by the use of different varieties or by alteration in the method of cultivation. The writers do not feel prepared as yet to recommend the making of sunflower silage on a large scale for feeding to stock.

J.J.G.

Vitamins, Health and the Daily Diet.

J. W. REED and S. PALMER. *Arkansas Agric. Expt. Sta. Bull.*, 1923, 184, 5-64.

A general discussion of the relative vitamin and protein values of the more common foods, other dietary factors, and considerations involved in adequate nutrition under various conditions. J.J.G.

Vitamin Studies. IX.

The influence of the diet of the cow upon the quantity of vitamins A. and B. in the milk.

CORNELIA KENNEDY *and* R. A. DUTCHER. *J. Biol. Chem.*, 1922, 50, 339-59.

Two types of milk, one produced on a diet known to be deficient in its vitamin content, and a second representing that produced on a ration carrying ample amts. of vitamins A. and B., were fed to rats in such a manner as to demonstrate possible differences in their vitamin content. Milk produced on a poor diet was deficient in both vitamin A. and B., but milk of satisfactory quality could be produced without access to pasturage.

J.J.G.

Vitamin A; The Origin of—in Fish Oils and Fish Liver Oils.

J. C. DRUMMOND, S. S. ZILVA, KATHERINE COWARD. *Biochemical Journal,* 1922, 16, 518-522.

The origin of the vitamin A. in fish oils and fish liver oil has been traced back to the synthetic powers of the marine algae which form the fundamental food supply of all marine animals. J.J.G.

Vitamins in Agriculture.

By J. GOLDING. University College, Reading, *Bulletin XXXII,* 1923.

A brief review of the results of some experimental work on vitamins. J.J.G.

Vitamin A. and Vitamin C.; The Requirements of the Pig for.

J. B. ORR and A. CRICHTON. *J. Agric. Sci.,* 1924, 14, 114-25.

From a rather extended study it is concluded that the requirements of the pig for these two vitamins is so low, that during the usual fattening period, *i.e.,* between weaning and slaughter, there is little likelihood of pigs suffering from vitamin deficiency under practical feeding conditions. J.J.G.

Wheat Offals; Their Grading, Composition and Digestibility.

H. E. WOODMAN. *J. Agric. Science,* 1923, 13, 483-507.

Chemical analysis, and size grading of particles of various offals showed that a fairly definite division may be made into three groups characterised by bran, middlings, and fine middlings. The carbohydrate content and to a lesser extent the protein content increase through the groups in the order named. The crude fibre varies in the opposite direction. Animal nutrition experiments with sheep, using the graded offals, are described. Little difference was found between the food values of ordinary and "broad" bran. Digestibility figures for organic matter, ether extractives, and carbohydrates increased with decreased size of particles. Protein digestibility was almost as good for bran as for the finer particles. The exceptionally high feeding value of fine middlings is noted. J.J.G.

CROPS AND PLANT BREEDING.

Absorption of Salts by Plants; The effect of Transpiration on the.

WALTER C. MUENSCHER. *American Journ. Bot.* (*Botanical Abstracts,* Vol. 12, No. 2, Feb., 1923), 9, 311-329, 1922. [See extracts for details of expt.]. Work done with pure line of Barley grown in Knop's soln.

When transpiration was reduced to less than half by increasing humidity, total ash content of plants remained essentially the same. Shading reduced transpiration but reduced photosynthetic activity also, and, therefore, total ash content. Increased concentration of nutrient soln. reduced transpiration markedly, but ash content hardly at all. The ash content expressed in percentage of total dry weight of the whole plants varied but slightly, regardless of whether the plants were grown under conditions of high or of low transpiration, and irrespective of how transpiration was reduced.

These results show that there is little or no relation between transpiration and absorption of salts in barley, and they do not support the theory that transpiration plays an important rôle in supplying the plant with nutrient salts. The amount of growth seems to be an important factor in determining the amount and rate of entrance of essential salts taken up. R.A.R.

Ascent of Sap; The Physiology of the.

J. C. Bose (London: Longmans, Green & Co., 1923, pp. xv, +277, figs. 95). [*Experiment Station Record*, Vol. 49, 1923].

The result of these researches is to prove the existence of active pulsating cells throughout the length of the plant, in and from the absorbing root to the transpiring leaf. It is the pumping action of the cells that gives rise to the physiological conduction of sap, even in the absence of root pressure and transpiration; it also injects liquid into the xylem setting up an intravascular pressure with the consequent mechanical transport of fluid.

The situation of the active cells has been localized by means of the electric probe; the cellular pulsations concerned in the ascent of sap have been recorded by an automatic method. The invisible changes in the interior of the plant have thus been revealed, and the effect of the changes of the environment determined from the responsive variations in the pulse record. R.A.R.

Breeding Crop Plants.

H. K. Hayes and R. J. Garber. McGraw-Hill Book Company, 1st Edition, 1921.

In their preface, the authors state that " the purpose of this book is to present fundamental principles of plant breeding and to summarize known facts regarding the mode of inheritance of many of the important characters of crop plants." In spite of the fact that in the list of literature cited, given at the end of the book, a few papers published in 1921 are mentioned, since the book itself was published in that year, it is clearly not intended that a full summary beyond, say, 1919 should be made. Thus the book should be considered as summarising known facts up to about 1919.

In Chapters I—V, reference is made to the work of early investigators, and the essential contributions of Darwin, Weissman, De Vries, Johannsen, and Mendel are mentioned, leading up to plant genetics, the mode of reproduction in relation to breeding, field plot technique, and controlling pollination.

Chapters VI and VII deal mainly with classification of and inheritance in Wheat, Oats and Barley. It is shown that the inter-relationships of the so-called wheat species are of considerable complexity, but *Triticum vulgare* and *T. compactum* appear to intercross quite readily and from this cross some results have been obtained touching upon the inheritance of density of spike. Certain workers in this field have considered that only one factor is concerned, while others have concluded that density of spike is determined by at least three pairs of main factors, together with other minor ones.

In inter-varietal crosses, contrasting white grain with red, the former has been found to be recessive but segregation in F_2 may be 1:3, 1:15 or even 1:63, thus indicating that red colour may be due to one, two or three independent factors. Seed texture has been studied by means of inter-specific crosses, but the results obtained from crosses between *T. vulgare* and *T. turgidum* do not seem quite to agree with those obtained when *T. vulgare* and *T. durum* were used. While some results indicate that there is only one factor difference, with or without dominance of hard grain, others show that the case is less simple.

In intra-varietal crosses with *T. vulgare*, red glume is dominant over white, inasmuch as the F_1 is reddish, and in F_2 one white to three red or reddish is obtained. There appears, however, to be more than one type of

true-breeding red, so that the question is not considered as fully investigated. In crosses between *T. vulgare* and *T. durum* a 15:1 segregation has been obtained in F_2.

In some wide crosses, linkage has been found between hairiness and colour of glume, and in some such crosses also a factor for very long glumes appears to inhibit full development of hairs. It is shown, however, that hairiness of glume is not always linked with a particular glume colour. No cases of simple monohybrid segregation for hairiness of glume are quoted. In Indian varieties two distinct types of hairiness of glumes have been found. When these two types were crossed segregation in F_2 was of the type fifteen hairy to one smooth.

When fully bearded wheat has been crossed with true breeding wheat which is not fully bearded, simple monohybrid segregation of one fully bearded to three not fully bearded has been obtained, but it is recognised that this does not fully cover the whole question, since types which are true-breeding, not fully bearded, are not uniform in extent of awn development.

Some results indicate that susceptibility to Yellow Rust is dominant over resistance and that in F_2 monohybrid segregation may be obtained. Other results, however, indicate that inheritance with regard to this character may be more complex.

The study of resistance to Black Rust is complicated by the fact that a single racial form of the fungus may behave differently in various crosses.

Resistance to Bunt is an inherited character, but inheritance is complex. It has been found possible, however, to breed desired types resistant to this disease.

There is some indication, also, that winter-hardiness and standing capacity are characteristics which can successfully be dealt with by wheat breeders.

In Oats, full awn development is not obtained in F_1. when fully awned is crossed with awnless, but in F_2, every fourth plant is again fully awned.

Colour of grain (paleæ) is rather complicated in oats. The four types, black, grey, yellow and white, have been considerably studied. In the presence of black, none of the other colours show, but black grain may itself be due to either of two independent factors. When only one is present and a cross with white is made, segregation in F_2 is of the monohybrid type, but when both are present a 15:1 ratio is obtained in F_2.

Similarly there are two independent factors for yellow, each of which is apparently hypostatic to grey, but epistatic to white. The fact that there exist two independent factors for black and two such for yellow has led to some interesting results.

Red straw in oats is dominant over colourless and in F_2, a segregation of three red to one colourless has been obtained.

In all oat species except *Avena nuda* the kernel is trapped within the palea. When the two types are inter-crossed, the F_1 obtained is intermediate and a 1:2:1 segregation ratio has been obtained in F_2. There is some suggestion, however, that a secondary factor may be concerned with the proportions in which each type of grain are found in different heterozygous plants.

When a type with the basal grain articulation known as "wild base" is crossed with the "cultivated" type, the F_1 is intermediate, and in F_2 the ratio 1:2:1 is usually obtained.

In a cross between fully open and full Tartarian types, the panicle in F_1 is intermediate. It appears, however, that two pairs of factors are concerned and that fixed intermediate types can be obtained in F_2 together with true breeding, fully open, and full Tartarian.

Some results indicate that the oat breeder can produce types resistant to Crown Rust, while resistance to Black Rust is a dominant character with a segregation of three resistant to one susceptible in F_2.

Table XVI gives in convenient form some results obtained in the study of inheritance in barley, and its main features are here reproduced:—

Character differences.	F_1.	F_2.
Awnless *vs* Hooded	Awnless	3 Awnless, 1 Hooded
Hooded *vs* Awned	Intermediate Hooded	3 Hooded, 1 Awned
Rough *vs* Smooth Awns	Rough	3 Rough, 1 Smooth
Black Palea *vs* Colourless	Black	3 Black, 1 Colourless
Purple Palea *vs* Colourless	Purple	3 Purple, 1 Colourless
Covered Grain *vs* Naked	Covered	3 Covered, 1 Naked

Spring habit in barley has been considered by some workers to be dominant over winter habit. Results for density of ear have not always agreed, but there appears to be more than one pair of factors concerned. No great encouragement has been met with in breeding for a high yielding awnless barley, but it seems that a high yielding smooth awned type is possible.

Some results obtained with Rye, Buckwheat and Rice are also summarised, and in Chapters VIII to XIV much valuable information is given with regard to selection and crossing (mainly in connection with methods of procedure rather than hand technique), the economic results obtained by means of selection and crossing in normally self-fertilised crops, such as Wheat, Oats, etc., and also crops which are as yet of no immediate importance in this country, such as Cowpeas, Flax, Tobacco, Maize, etc.

In Chapter XV, Grasses, Clovers and Alfalfa are briefly dealt with. Of the grasses, Timothy is chiefly considered, and information concerning methods and results of selection and line breeding are given.

Some results show that "*Trifolium pratense* will set practically no seed when protected from the visits of insects, particularly bumble bees." Adverse climatic conditions may affect fertility apart from their influence upon the work of insects. It is suggested that a restricted form of mass selection is the most suitable method for dealing with this crop.

It is stated that *Medicago sativa* and *M. falcata* cross readily, and it has been suggested that Grimm's lucerne is a derivative of this cross, *M. sativa* set more seed when cross-pollinated than when selfed but selfed plants set considerable seed.

Chapter XVI is devoted to Potato Improvement. The origin of the cultivated potato is discussed, followed by statements of results obtained in breeding experiments. It would appear that white skin colour in the tuber is a recessive character, but several factors are concerned with tuber coloration. Long tuber is dominant over round and apparently one pair of factors is concerned. Anther sterility is probably a complex character, but sterility has been found to be dominant. Shallow eyes are dominant over deep eyes.

The production of new forms, the difficulties of obtaining crossed seeds, and other matters relating to potato improvement are also discussed.

In the remaining three chapters, the breeding of vegetables and fruit plants, together with farmers' methods of producing pure seeds, come under consideration.

The book accomplishes the aim stated in the preface and forms an exceedingly valuable store of information. Owing to the very wide field covered, very little room is left for detailed discussion, and this, of course, was not intended.

To the uninitiated, the list of definitions given is valuable, while the list of literature cited leads those who wish to be led into a remarkably wide field of literature touching upon plant breeding. The book is also well indexed T.J.J.

Ensilage: Crops for.

A. W. OLDERSHAW, County Hall, Ipswich. *Journal of Royal Agricultural Society of England*, 1923, Vol. 84, pp. 39-49.

In the Eastern and Midland districts of England and probably in many parts of the South and S.W., autumn sown crops grow a bigger weight of material than spring sown crops. In Northern and Western districts it may very often happen that spring sown crops will prove more satisfactory.

As a result of two years' trials on heavy land in Suffolk, the opinion was formed that a very useful mixture per acre would be 1 bushel of tares, ½ to 1 bushel of beans, and 1 bushel of winter oats. For this purpose "Marvellous" winter oats, being very strong in the straw, are well worth a trial. Experience elsewhere shows, however, that they are somewhat deficient in tillering powers compared with ordinary winter oats, hence they should as yet be used with caution.

On poorer heavy land, 2 bushels of tares, ½ bushel winter beans, and ½ bushel of oats per acre are suggested, the high proportion of leguminous plants adding more considerably to the nitrogen supply in the soil.

On poor land, where a very heavy crop is not probable, a larger proportion of tares may be included.

The suitability of other crops, such as Peas and Oats, Lucerne, Clover, Clover and Ryegrass Mixed, Maize, Sunflower, Lupins and Buckwheat, and Grass are also discussed. R.A.R.

Field Experiments; Unavoidable Error of.

O. T. FAULKNER. *Agr. Jour. India*, 18 (1923), No. 3, pp. 238-248.

In laying out plots so as to get from a given area of land results which shall be affected as little as possible by unavoidable errors, it is recommended that only adjacent plots be compared. It is also recommended that the width of plots should be as low as possible consistent with other considerations, such as reduction of edge effect. An increase of length of plot without a corresponding increase of width lessens the standard error, the optimum ratio between length and width being 5 to 1. R.A.R.

Red Clover; Self Fertility in.

E. N. FERGUS. *Kentucky Station Circ.*, 29, pp. 19-36. (*Experiment Station Record*, Vol. 49, 1923.

Seeds from artificially self-pollinated red clover plants were sown. Some half of them produced normal plants, which in turn were self pollinated when coming into bloom. The progeny from the parents yielding the larger number of seeds under self-pollination produced large numbers of seeds themselves when self-pollinated, while the reverse was the case with

parents bearing few seeds. From these observations and observations on the production of abnormal seedlings, particularly those deficient in chlorophyll in the F_1 generation, it is argued that self-fertile lines exist in red clover. R.A.R.

Unification of Methods in Seed Testing; General Views as to its importance for the Trade, and especially with relation to the Purity of the Seed.

W. J. FRANCK. *Cultura* 34, 270-280, 1922. (*Botanical Abstracts*, 1561, Vol. 12, No. 3, March-April, 1923).

In the seed trade of the Netherlands, the following formula has been much in use:—

$$\text{Usefulness} = \frac{\text{purity} \times \text{germinating power}}{100} - 3 \times \text{harmful impurity.}$$

R.A.R.

Yield, Composition, and Quality of Wheat; Effect of various Inorganic Nitrogen Compounds, applied at Different Stages of Growth, on the.

J. DAVIDSON and J. A. LE CLERC. *Journal of Agricultural Research*, Vol. XXIII, No. 2, 1923.

In an experiment carried out in Nebraska, with a hard winter wheat to determine the effect of nitrogen derived from carriers other than sodium nitrate, the following conclusions were come to:—

1. "The application of nitrogen in any of the inorganic forms used at the early stages of growth was instrumental in producing the highest yields of wheat."
2. "The application of nitrogen in any of the inorganic forms used at the time of heading was instrumental in producing the best quality of grain with reference to protein content. It also produced a high protein content in the straw."
3. "No difference could be observed in the effect of the different forms of inorganic nitrogen."
4. "The application of nitrogen at the first two stages caused a depression of the phosphoric-acid content of the grain, as well as in the straw."
5. "The application of nitrogen, at the first two stages of growth, caused a marked depression of the ash and silica content in the straw."

R.A.R.

DAIRYING.

Clean Milk Competitions; Guide to the Conduct of.

Miscellaneous Publications, No. 43. Issued by the Ministry of Agriculture and Fisheries.

This monograph should prove of great value as a guide to all who are responsible for the organisation and running of Clean Milk Competitions. The booklet embodies the considered judgment of a Committee appointed by the Ministry and gives an outline of a scheme for a Competition as well as the following helpful Appendices:—

A. Specimen entry form.
B. Method of taking Samples.
C. Bacteriological examinations.
D. Keeping Quality Test.
E. Fat Test.

F. Inspection Report Card.
G. Specimen Interim Report of Farm Inspections.
H. Specimen Certificates of Merit.
J. Statement showing the provision made for the Bacteriological Examination of Milk at Provincial Agricultural Colleges and University Departments of Agriculture.

This Standard Guide should assist very considerably towards uniformity in the carrying out of Clean Milk Competitions in various parts of the Country.

The first Clean Milk Competition was held in Essex in 1920, followed by further competitions in 1921—2 and 3. Sussex followed in 1921 and 1922, Buckingham in 1922 and 1923 and Kent in 1923.

This year several other counties have arranged for Clean Milk Competitions, whilst others who would have done so have been prevented owing to the prevalence of Foot and Mouth Disease in their areas. E.H.

Handling of Milk; Studies Concerning the.

By the Staff of the National Institute for Research in Dairying, University College, Reading.

Miscellaneous Publications, No. 41. Issued by the Ministry of Agriculture and Fisheries, 10, Whitehall Place, London, S.W. 1.

The subject chosen for this first monograph is of particular interest at the present time in the light of the Milk and Dairies (Amendment) Act, 1922, and the attention which is now given to the production of clean milk. The book has been written in as simple language as possible, and the use of scientific terms has been reduced to a minimum in order that it may be readily intelligible to all classes of readers. It should appeal to a wide public—dairy farmers, milk distributors and sellers, medical men—and, it is to be hoped, to some at least of the milk consuming public, who are not professionally interested in it. Milk is not consumed either in sufficient quantity or in such a condition of cleanliness as to promote, as it might promote, the health and well-being of the people, who cannot afford to be ignorant of how it is produced and distributed, and of how those things might be better done with advantage to producer and consumer alike. E.H.

Reductase—Fermentation Test.

Dairy Adviser.

This test, which has been perfected by the distinguished Danish Scientist, Prof. Dr. Orla-Jensen, provides a definite means of estimating the purity and cleanliness of milk. In the reduction test, the number of bacteria present is estimated by the length of time required to reduce a methylene blue solution of known strength to a colourless body.

To 40 c.c.'s of the milk to be tested, 1 c.c. of methylene blue solution —methylene blue for making a standard solution can be had in tablet form—is added.

Class I milk keeps its colour for 5½ hours or more.
Class II milk keeps its colour for 2 hours and less than 5½ hours.
Class III milk keeps its colour for more than 20 minutes and less than 2 hours.
Class IV milk keeps its colour for 20 minutes or less.

Note.—Milk placed in Class I, II or Class III, respectively, is lowered a class if it has a decidedly bad smell or taste.

On the other hand, the fermentation-test, in which the milk is simply left for 20—24 hours at a given temperature, shows whether the good lactic acid bacteria curdling the milk into a fine solid porcelain—like jelly, or the obnoxious gas producing bacteria, causing the curd to be bubbly and spongy, prevail.

The reduction-test thus being a purely bacterial quantitative determination and the fermentation-test to a certain extent a qualitative determination, it is possible by combining these two tests in the so-called Reductase-Fermentation test, to determine approximately both the number and kind of bacteria present. E.H.

ECONOMICS.

Agrarian Revolution in Roumania.

IFOR L. EVANS. Cambridge University Press.

This work describes one of the most far reaching changes in the social and political structure of European society, namely the agrarian reforms of the eastern half of the continent. The overthrow of the Tsarist regime in Russia was followed by the confiscation of the large estates. Legislation to improve the lot of the rural worker and to establish peasant proprietorship on a large scale was introduced soon afterwards in all the border states. The estates of the large landowners were expropriated, and the centre of social gravity changed. The peasant has come into his own. The immediate effect has been to convert one of the granaries of Europe into a region from which the exports of grain have become negligible. It is impossible yet to state what the permanent effects of the revolution will be. The chapter headings give an indication of the scope of the book. They are:—The Agrarian History of Roumania, Agrarian Conditions on the Eve of Reform, The New Agrarian Laws and Their Application, Agricultural Production since the War, Economic Consequences of the Reform, General Consequences of the Reform, The Historical Perspective.

W.K.

Agricultural Economics; Foundations of.

J. A. VENN. Cambridge University Press.

The book is an attempt to bring within reasonable compass some account of the origin and incidence of the numerous economic problems which affect the agricultural community. First is given a description of the methods of land tenure adopted at different periods in this country and in others. This is followed by an account of the economics underlying its division. and of the burdens, such as tithes, rates and taxes, it has been called upon to bear. A short history of the productivity of British agriculture before and during the war is then given. The utilisation of man power on the land, and the marketing of produce also find a place in the book.

The volume deals chiefly with matters of agricultural history, and the title is, therefore, a good description of its contents. W.K.

Agricultural Industry; The Proper Position of the Landlord in relation to the.

THE LORD BLEDISLOE, K.B.E. *British Association,* 1922. Section M. (Agriculture).

"The agricultural community in Britain to-day, above all else, needs enlightened leadership, just as agriculture needs efficient organisation, and the landlord, if after due training, he would but take his proper position, should be both leader and chief organiser." The address goes on to state

that the divorce of land ownership from land cultivation is a deterrent to the full development of agricultural land. If occupying ownership be impossible, then good tenants should be secured in their holdings. Methods for the improvement of British agriculture are given at great length. Lord Bledisloe favours the provision of factory equipment on estates, so as to make them self-contained industrial units, supplying themselves with requisites and making their own butter, bacon and cheese. Unless the land owner is ready to take the lead in directions of this kind, then the present system of land ownership will decay. At the present time, material resources do not admit of such developments, and there is also the heavy burden of local and Imperial taxation. W.K.

Agricultural Produce; Distribution and Prices of.

Reports of the Departmental Committee presided over by the MARQUESS OF LINLITHGOW, in one Volume, published by His Majesty's Stationery Office.

1. Milk and Milk Products.
2. Fruit and Vegetables.
3. Meat, Poultry and Eggs.
4. Cereals, Flour and Bread.
5. Final Report.

Reports 1 to 4 deal with the methods and costs of distribution, wholesale and retail, and are packed with information on these points. In its final report the Committee states that "our investigations have led us to the conclusion that the spread between consumers' and producers' prices is unjustifiably wide." "Economies can be made and processes of collection and distribution can be shortened." The producer has need to develop a marketing sense and to learn the importance of standardising his produce. Co-operation amongst farmers for selling their produce should be encouraged. Reasons are given for the failures of the past. The reports will repay careful study. W.K.

Agricultural Tribunal of Investigation.

Interim Reports, 29th March and 10th November, 1923.

Final Report, 7th May, 1924. Published by His Majesty's Stationery Office.

The Tribunal was appointed in December, 1922, to "enquire into the methods which have been adopted in other countries during the last fifty years to increase the prosperity of agriculture, and to secure the fullest possible use of the land for the production of food and the employment of labour at a living wage; and to advise as to the methods by which those results can be achieved in this country." The interim reports were concerned with the steps which should be taken with a view to the immediate assistance of agriculture, long period causes were discussed in the final report.

The Final Report, consisting of three main divisions, is a valuable survey of agriculture and its place in the national life. The members of the Tribunal show differences of opinion, Sir William Ashley and Professor Adams believe in direct State Assistance; Professor Macgreggor in more self-help on the part of the farmer, and education through colleges and farm institutes. Reference is made to the universality of the co-operative movement in all countries except Great Britain. Special mention is made of societies for insurance and credit. Credit should be systematised by

the institution of Farm Loan Boards. The co-operative method is not defeated by a home market; Denmark, Germany and Holland, as well as other countries have adapted their organizations to national conditions, and differ from one another in many particulars.

During the past half-century, the cultivated area in Great Britain, France and Germany has decreased slightly, in Denmark and Holland there has been a substantial addition to the area. Although since 1870 there has been little change in the total area under crops and grass in Great Britain, marked alterations have taken place in the proportion of the one to the other. There has also been a decrease in the production of roots and green crops; in other countries, almost without exception, there has been an increase in the area under these crops.

England and Wales still hold the premier position in respect of farm animals. The outstanding features are the increase in the number of cattle and sheep, and the very stationary character of the pig population. The Tribunal is strongly of opinion that the best chance in this country is through the extension of arable stock farming and milk production. The problem of employment in agriculture receives attention in the two main sections of the report, while Sir Thomas Middleton, who was not a member of the Tribunal, contributes an interesting appendix on the same subject. In Great Britain, between 1871 and 1921, there was a considerable reduction in the number of persons employed in agriculture, and a decline in women workers greater than in any other European country. A comparison of wages with European countries is difficult, because there the small holder preponderates, and agricultural labourers are few. Professor Macgreggor is strongly of opinion that farming must be made an economic and paying proposition, if people are to take part in it. This fact, coupled with first, small holdings and the personal touch with the soil which accompanies them, and secondly, that tillage employs more men and feeds more persons than grass, sums up the Tribunal's views on production and employment.

Professor Macgreggor agrees with those who hold that railway companies in Great Britain give preferential treatment to foreign and colonial produce. The public ownership of railways in foreign countries has certainly contributed to the development of agriculture.

Electric power is now widely used throughout the Scandinavian countries, and in many parts of France, Germany, Italy and other states. The broadcasting by wireless of weather reports, market news, and other information is a feature in America.

The Forestry Commissioners contribute an appendix. W.K.

Agriculture at Home and Abroad; Economic Condition of.

DR. ARTHUR G. RUSTON. *Journal of the Farmers' Club, April,* 1923.

The lecturer's conclusions are based upon an investigation of 52 farms in Yorkshire, showing a wide range of types. His statement that the most productive size of holding in Yorkshire is 150 acres, was criticised by some of those present. The influence of the proportion of grass to arable, and of the variety of crop sown, was exhibited in the financial returns of these farms. Dr. Ruston said that during the next few years, the mainstay of successful farming must lie in livestock. Salvation will come, also, more as a result of organisation amongst farmers themselves than from

direct Government assistance. Emphasis was laid on the individuality and personality of the farmer, and upon the extreme value of some form of accounts and records. W.K.

Agriculture; Electricity in.

ARTHUR H. ALLEN. *Pitman's Technical Primers.*

A small book indicating the scope of electrical power in agricultural activities. There are chapters on the supply and distribution of power, its use in the house, the field, the dairy, the incubator and for electro-culture. W.K.

Applied Economics; Essays in.

BY PROFESSOR A. C. PIGOU. P. S. King and Son.

Essay V. *A Minimum Wage for Agriculture.*

Basing his argument on the "tradition of English legislation that the State shall not interfere in private industry except with the purpose of remedying some definite abuse," Professor Pigou examines the statements that agricultural labourers receive less than a "fair wage," and less than a "living wage," by no means identical statements. He holds that the general conditions of life of the labourers are such "that farmers, if they wish to be unfair, are so situated that their will cannot readily be thwarted." It is clear, he says also, "that many agricultural labourers must be earning less than is required to maintain the full physical efficiency of themselves and their families." He shows how the establishment of Wages Boards is likely to lead to either good or bad results, according to the manner in which they interpret their functions, and the conditions prevailing in their localities. Again, "the legal enforcement of a living wage in agriculture, in excess of what for most districts would be the fair wage, is, on such evidence as we possess, more likely to injure than to benefit agricultural labour as a whole."

Essay IX. *Small Holdings.*

Professor Pigou shows how the character of farming determines the size of the holding. General influences are now in many respects favourable to small holdings. Land yields, however, "amenities," such as social prestige, sport and hunting, the value of which depends, in part, on the size of the holdings into which it is divided. These latter factors are now becoming less important. The legal costs and economic friction of changing the size of the holdings retards progress; hence it is necessary, not only that small holdings should be economically superior, but that their superiority should be great enough to compensate for the trouble, costs and risks of transition. A full development of allotments and small holdings is socially advantageous, and State action is necessary to bring it about. The writer argues that "a given sum of public money could accomplish more in setting up small tenants than it could do in setting up small owners." W.K.

British Wool; Commercial Outlets for.

COL. THE HON. F. W. WILLEY, C.M.G., C.B.E. *Journal of the Farmers' Club.* May, 1923.

The lecturer spoke of the British and World's sheep population, and followed with the characteristics and predominant uses of British wool. He showed that the wool consumption per head in Europe to-day is probably less than before the war, and concluded with some remarks on marketing and the "get-up" of the British clip. W.K.

Co-operative Marketing. The Golden Rule in Agriculture.

HERMAN STEEN. American Farm Bureau Federation.

The author, in his introductory note, states that more than 1,000 million dollars' worth of the 1922 farm products of the United States were marketed through co-operative associations. Co-operative marketing rewards producers with improved prices and facilities in marketing, reduces materially the cost of distributing goods, and benefits consumers by furnishing them with high quality products often at lower prices. This volume tells the story of more than 100 of the most important associations in the United States, and gives information on some of the leading Canadian societies. W.K.

Economic Survey of a Rural Parish.

J. PRYSE HOWELL. Oxford University Press.

"It is an intensive but unpretentious study directed to the elucidation of such elementary facts as the style of farming, the distribution of holdings, the intensity of labour and of production, the standard of farm equipment, housing conditions, and the value of property."

"Nothing is likely to conduce to a clear view point and to a reliable basis for action as first hand investigation of the problem."

[*Extract from the Introduction*].

W.K.

Methods of Farming; How to adapt to the Changed Conditions of Agriculture.

MR. JAMES WYLLIE. *Journal of the Farmers' Club.* April, 1924.

The present state of agriculture was summed up by the speaker in the following words: "The disease from which agriculture is suffering may be readily diagnosed as low selling prices of farm products in relation to the buying prices of the raw materials and the cost of living or general level of prices; while the symptoms fall under three heads,

1. Low wages to the workers.
2. Low profits or losses to the farmers; and
3. Small returns, or no returns at all, to the landlord;

all in relation to the present value of money."

Obstacles to improvement,

1. Lack of confidence in future prices.
2. Lack of capital.

The economic limit has not yet been reached on the majority of farms. Land which is so poor as to be just beyond the economic margin of cultivation, can be brought within the margin, just as effectively by improved methods of cultivation, manuring, seeding, etc., as by a rise in the price of wheat. Low prices must be counterbalanced by improved methods of farming.

A very spirited discussion followed the reading of this paper.

W.K.

Population and the Food Supply.

1. *Mankind at the Crossroads.* BY EDWARD M. EAST.

(Charles Scribner's Sons, 16/-).

The theme of this book is the pressure of population on the world's supply of food. The Rev. T. R. Malthus, at the end of the 18th century,

predicted that population would soon grow beyond the available supply of food. Malthus did not foresee that steam power and the consequent revolution in transportation would bring to this country food from distant sources of supply. World population has grown from 850 millions in 1800, to 1,700 millions to-day. Professor East holds the view that if the present increase continues, the result will be poverty, misery, a depressed standard of life, and ultimately starvation. He says that "Man stands to-day at the parting of the ways." The book is concerned chiefly with population questions, but is of greater interest to agriculturists.

2. *Edinburgh Review.* April, 1924.

Article by SIR HENRY REW on "The World's Food Supply."

This contributation is a review of Professor East's book, and others dealing with the same subject, notably "The World's Food Resources," by Mr. J. Russell Smith. The writer questions the assumptions of Professor East that only 40 per cent. of the land area of the globe can support human beings in the ratio of one person per 2½ acres, and that the present rate of population is likely to be maintained. Present statistics are limited, and detailed deductions from them extremely uncertain, but figures point to the conclusion that up to the present time, food producing areas have increased in a higher ratio than the increase of population. The fall in food prices for the past 40 years shows that there has been no pressure of population on supplies. The progress of medical science will make tropical lands more habitable and thus increase the area available for food cultivation; and plant-breeding promises a potential increase of from 25 to 50 per cent. on existing land. The writer shows further that the use of land for the production of animal food is extravagant, and that a change of human dietary to a more vegetarian character will improve matters in this direction. There is also the harvest of the sea. There is no danger in this generation. but, taking the long view, the march of humanity is towards the exhaustion of the world's food resources, hence the need for intelligence and research.

3. *The Economic Journal.* The Quarterly Journal of the Royal Economic Society. Articles by SIR WILLIAM BEVERIDGE and MR. J. M. KEYNES.

The latter holds that Great Britain as a manufacturing nation is finding it more and more difficult to exchange profitably her industrial products for the food of her people. This is not due to the aftermath of the war, says he, but was beginning to make itself evident as far back as 1900. Sir William Beveridge, while not sharing in full the views of Mr. Keynes, feels that the problem of numbers remains, but suspends judgment until more data is available of the potential agricultural resources of the world, and of the social effects of the restriction of population. W.K.

Rural Education.

ARTHUR W. ASHBY and PHOEBE G. BYLES. *A Report on an Inquiry conducted in 1920, under the auspices of the Oxford National Education Association and the Horace Plunkett Foundation.*

Oxford being a county with no large towns and no important industry but agriculture, the problems faced are common to most rural areas. The volume is in two parts, the first dealing with Elementary Schools, and the second with adolescent and adult education. The investigation has been

well conducted, and the results should prove of great interest to those working for improved educational facilities in country districts.

W.K.

Where Farming Pays, and Why.

W. Meakin.

Denmark is the country which has attracted the author's attention, and he has compressed into about sixty pages a clear account of the main features of the co-operative economy of that country. Mr. C. S. Orwin contributes an introduction. The chapter headings show the subjects treated: Small-holders and Co-operation, Electricity on the Farm, The Village Creamery, The Bacon Factories, A Vast Egg Industry, A Co-operative City Milk Supply, How Success has been Achieved.

Education, reform of land tenure, and co-operation are stressed in this small volume. W.K.

ENTOMOLOGY.

Acarine Disease Explained.

(For a description of this disease see Ministry Leaflet No. 395).

Rennie. *Bee Diseases Investigation Memoir,* No. 6. The Bon Accord Press, Aberdeen.

The author discusses in some detail, Acarine disease from all practical aspects, and concludes with perhaps the most important aspect from the point of view of the bee-keeper—"Hopes of Deliverance." Here he deals with limitation of spread; Anti-Acarine management; Radical treatment of diseased stocks; and preventive treatment of diseased stocks.

J.R.W.J.

Agricultural Zoology of North Wales; Preliminary Report on the.

Walton. University College of North Wales, Bangor.

The report gives a list of the pests of farm stock, and of farm, garden and orchard crops, encountered during a three year survey of the Counties Anglesey, Carnarvon, Denbigh and Flint. The damage done to the animal or plant host is described, as are the general distribution of the pests, as far as ascertained, and the steps taken to deal with them. J.R.W.J.

Apple Blossom Weevil; Control of the.

(For a description of this pest see Ministry Leaflet, No. 15).

Miles. *Journal of Pomology and Horticultural Science.* III, 1, Nov., 1922.

As a result of the described experiments, the author suggests that to control this pest, the trees, if encrusted with moss, lichen, etc., should first be cleansed with a caustic winter wash. This should be followed by an annual spraying with lime sulphur, and, if numbers of insects are found hibernating on the trees, spraying during the dormant season with 10 per cent. paraffin emulsion. It is pointed out that complete control cannot be obtained by a single operation, and attention is drawn to the value of banding with sacking during March and April. J.R.W.J.

Apple Blossom Weevil; The Control of the.

Massee. *Journal of Pomology and Horticultural Science.* IV, 1, July, 1924.

The author describes a large number of experiments on the control of these pests, and clearly demonstrates the value of the sacking band method of trapping the weevils. The bands should be put on, if possible, by the end of May, and should be removed during December and January, and the weevils destroyed. J.R.W.J.

Carrot and Onion Flies.

(For a description of these pests see Ministry Leaflets, No. 38 and 31).

SMITH. *Insect Pests of the Horticulturalist, their Nature and Control,* Vol. I.

The author describes a very comprehensive series of experiments on the artificial control of these pests by the prevention of oviposition. He shows that by a combination of late sowing (late May), and the use of appropriate dusts, as many as 95 per cent. clean carrots may be obtained, when the untreated plots carry crops varying from 20 per cent. to complete loss. In the case of the onion fly, 68 per cent. of clean bulbs was obtained.

Amongst the successful materials are:—Green Tar Oil, Heavy Cresylic, or Heavy Creosote, combined with sand or precipitated chalk; Naphthalene and Soap Snuff mixed; and Soot and Derris Powder mixed. J.R.W.J.

Celery Fly.

(For a description of this pest see Ministry Leaflet, No. 35).

GARDNER. *Insect Pests of the Horticulturalist, their Nature and Control,* Vol. I.

The life history of the Celery Fly is treated of in detail, and its economic importance discussed. Various methods of artificial control are suggested, including spraying during emergence periods to prevent oviposition, and leaving a few roots to grow into the second year to act as trap crops, it having been shown that the larger leaves of the trap crop were preferred by the fly for egg-laying. J.R.W.J.

Control of "Cutworms" by Poisoned Bait; Notes on the.

(See Leaflet No. 33, Ministry of Agriculture and Fisheries for a description of these pests).

FRYER and STENTON. *Annals of Applied Biology,* X, 2, July, 1923.

The authors describe laboratory and field experiments, designed to test the effectiveness of the "Poisoned Bait" method of controlling cutworms. The most attractive bait discovered was moistened bran, and the most successful poison, Paris Green. Under field conditions, the bait having been spread broadcast, or by a manure distributor, approximately 50 per cent. of the larvae present were destroyed. J.R.W.J.

Eelworm Disease of Potatoes caused by Tylenchus Dispaci.

GOODEY. *Journal of Helminthology,* I, 5.

Previous work on this disease, its occurrence in Britain, and its symptoms are discussed, and remedies suggested. Where an attack is to be feared, it is recommended that early varieties should be used as far as possible, as these have not, so far, been found to be susceptible.

Of the late varieties, King Edward seems to be only slightly attacked. Other recommendations are the use of undiseased seed, and the lifting of all diseased tubers, which should not be stored, but should be cooked and fed to stock. J.R.W.J.

Egg Killing Washes.

LEES. *Journal of Pomology and Horticultural Science,* III, 4, Jan., 1924.

The author describes an enquiry into the efficiency of various substances for the destruction of the eggs of Aphis pomi, the Permanent Apple Aphis. (For a description of this pest see Ministry Leaflet, No. 330).

It was found that Lime Sulphur at all strengths by itself was ineffective, but that Lime Sulphur with the addition of 2 per cent. calcium caseinate had a strong killing action at the strengths of 1 in 15, 1 in 20, and 1 in 30, whether applied in February or March. Other fluids releasing or containing finely divided sulphur or sulphur dioxide were comparatively ineffective.

Combinations of Caustic Soda and Nicotine had strong killing power if applied just before hatching, but were useless at an earlier date; and whilst certain of the coal tar products were toxic, most of them were inoperative, and some damaging to the plant. J.R.W.J.

Gout Fly of Barley; Chlorops Taeniopus (*Meig.*)

FREW. *Annals of Applied Biology*, XI, 2, July, 1924.

(For a description of this pest see Ministry Leaflet, No. 24).

The results of a very comprehensive series of observations and experiments dealing with the bionomics and control of this pest, lead the author to conclude that the Gout Fly passes through two generations per year, the winter one being passed mainly on Couch Grass, and the summer one on Spring Barley. The type of distortion caused depends upon the stage of growth of the plant when attacked, and the degree of distortion upon the rate of growth at the time of attack. Certain manures, particularly Superphosphate, are shown to have a very beneficial effect in reducing the infestation of summer barley, by their stimulating effect on the maturing of the ear, and the growth of the ear bearing internode. Whilst small dressings of nitrogenous manures may reduce infestation, large dressings will not reduce it, and may, by retarding the growth of the ear, increase infestation. Preventative measures suggested are early sowing of spring barley, good cultural conditions of the soil, and manuring with superphosphate or farm yard manure, to stimulate early growth. J.R.W.J.

Green Apple Aphis (Aphis Pomi. De Geer); The Resistance of Apple Stocks to Attacks of the.

(For a description of this pest see Ministry Leaflet, No. 330).

MASSEE. *Journal of Pomology and Horticultural Science*, III, 4, Jan., 1924.

The results of the experiments described, shew that different apple stocks vary in their degree of susceptibility to attack by this aphis. Any resistance possessed by a particular stock, however, does not appear to be transmitted to a susceptible scion worked on it, and vice versa.

J.R.W.J.

Insecticidal Properties of Derris Elliptica (Tuba Root); A Quantitative Study of the.

FRYER, STENTON, TATTERSFIELD and ROACH. *Annals of Applied Biology*, X, 1, Feb., 1923.

Tuba root, a constituent of the arrow poison of the Malays, was subjected to a critical study by the authors in order to satisfy a demand for a contact insecticide effective against caterpillars. They show that extracts of Derris elliptica have a high insecticidal value, particularly to caterpillars, but are not so toxic to aphides. The dry root itself may be used in a finely powdered condition, worked up with water together with soap or other emulsifying reagents; or the toxic principles of the root—"tubatoxin" and "derride"—may be used finely dispersed in water, their toxicity, since they are solids only slightly soluble in water, depending upon their degree of dispersion.

By means of a biological method of determining insecticidal properties quantatively, the authors succeeded in showing that to certain caterpillars, tubatoxin and derride are of the same order of toxicity as nicotine.

J.R.W.J.

Plant Parasitic Members of the Genus Aphelenchus; A Review of the.

GOODEY. *Journal of Helminthology*, I, 4.

The paper deals with eelworms belonging to the genus Aphelenchus, which cause diseases of cultivated plants. The structure of each parasite is described, together with the disease caused, and the symptoms of attack. A general discussion follows, on the problem of the appropriate treatment of these diseases, and the suggestion is made that some form of heat treatment of infective soils is likely to give the best results, owing to the fact that compartively low temperatures are lethal to the parasite. J.R.W.J.

Stem Disease Caused by the Eelworm Tylenchus Dispaci Syn. Devastatrix Kuhn; The Susceptibility of Clover and some other Legumes to.

GOODEY. *Journal of Agrcultural Science*, XII, 1, Jan., 1922.

(For a description of this pest see Ministry Leaflet, No. 271).

The results of experiments testing the suspectibility of various varieties and strains of Clover and other legumes, to attack by T. dispaci, enable the varieties to be divided into four groups varying in their degree of susceptibility. Group 1, containing all the varieties of Red Clover tested, together with Kidney Vetch and Swedish Cow Grass, is very susceptible to attack. Group 2, is widely separated from Group 1, and is much less susceptible. It contains English Cow Grass, and English and Canadian Alsike. Group 3, comprises varieties which are but very slightly susceptible to attack, viz., Sanfoin, and three varieties of White Clover. Lastly, Group 4, containing Sutton's Mammoth White, Lucerne, and Trefoil, appear to be insusceptible to attack.

These results have a practical bearing of considerable importance to the farmer whose land is infested with T. dispaci, as if he wishes to avoid stem disease he should not sow red clover, cowgrass, or alsike, but should make use of trefoil, lucerne, sanfoin, or a large white clover, such as Sutton's Mammoth White. J.R.W.J.

Successful Spraying and how to achieve it.

FRYER. Ernest Benn, Ltd., 1923. 7/6 net.

A handbook for the grower, treating mainly of the insect pests and fungus diseases of fruit trees and small fruits. The principles of "Contact" sprays for sucking insects, and "Stomach Poisons" for biting insects are explained, and methods of obtaining an efficient wetting spray described.

Fumigation is also dealt with, as are modern spraying appliances. The book concludes with a summary of the more important insect pests and fungus diseases, together with suggestions for their control.

J.R.W.J.

Turnip Gall Weevil. Ceutorrhynchus Pleurostigma, Marsh.

ISAAC. *Annals of Applied Biology*, X, 2, July, 1923.

(For a description of this pest see Ministry Leaflet, No. 303).

The author deals with the life history, bionomics, and larval anatomy of this pest of Crucifers, and describes attempts to obtain artificial control.

He recommends that in order to obtain control under field conditions, the following procedure should be adopted:—

All overwintered infested stalks of crops, such as brussles sprouts, kales, and cabbages, should be rooted out by the beginning of March, and of spring cabbages as early as possible. The earth should be shaken off and the roots stacked in large heaps, and burnt when dry. Infested stalks should never be left in the soil longer than can be helped, or, when they have been pulled up, left scattered about, or in small lots.

The land should be ploughed deeply immediately the infested crop has been removed, this will destroy a large number of pupae.

In the following autumn, a crop liable to attack should be avoided. It is not necessary to avoid such a crop in the spring or early summer, as the pest does not attack cultivated crucifers at this time,* but only crops grown from about the middle of July and through the autumn.

All Charlock and hedge mustard should be destroyed, as the adult beetles feed on the foliage and flowers of these plants.

* It should be noted that this rule is not invariable, since spring attacked cultivated crucifers have been observed. J.R.W.J.

Woolly Aphis; The Immunity of Apple Stocks from Attacks of.

(For a description of this pest see Ministry Leaflet, No. 34).

STANILAND. *Journal of Pomology and Horticultural Science,* III, 2, April, 1923.

The author describes experiments proving that different stocks vary in their powers of resistance to the Woolly Aphis, as regards both stem and root infection, and that a stem immune plant, such as Majetin, retains its immunity although worked on a susceptible root, such as Doucin Ameliore, Type V. J.R.W.J.

Zoological and Ecological Surveys and their Relation to Agriculture.

WALTON. *The Vasculum,* July, 1924.

The author discusses the nature, and scope, of such surveys, and the aims and methods of the Agricultural Zoologist, the value of whose work lies in the outlining and defining of pest zones, the forecasting of probable future outbreaks within such zones, and the prevention or mitigation of such outbreaks. J.R.W.J.

FORESTRY.

Artificial Seasoning of Wood.

South African Journal of Industry, 6: 131-132, 1923.

Methods of artificial seasoning of wood are discussed. The only method comparable with natural seasoning is the Otto Ozone process, which, it is stated, produces in a few days results indistinguishable from wood which has been air-dried for 10 years. W.S.J.

Australian Woods for Pulp and Paper Manufacture.

Bulletin of the Institute of Science and Industry of the Commonwealth of Australia. No. 25, 1923.

The possibilities afforded by Australian timbers for the production of paper-pulp for the manufacture of newsprint have been investigated during the last few years by the Institute of Science and Industry of the Commonwealth of Australia, and the results have been published in the above issue of the Institute's *Bulletin.* W.S.J.

Coniferae; A Handbook of.

BY W. DALLIMORE and A. BRUCE JACKSON. London: Edwin Arnold & Co. Price, 42s.

An authorative work, much of which is of a descriptive nature. In addition, the book contains much cultural information, and deals with insect and fungus pests and their treatment. The work is illustrated by drawings by Miss Lister, as well as by 32 full-page plates.

W.S.J.

Deodar Oil; Composition and Uses of.

Bulletin of the Imperial Institute, Vol. XXI, No. 3, 1923.

The *Bulletin* gives briefly the results of investigations conducted into the characteristics and possible uses of this oil. W.S.J.

Destructive Distillation of Wood.

BY H. M. BUNBURY. London: Benn Brothers, Ltd., 1923. Price, 35s.

The book discusses the development of the wood-distillation industry, varieties of wood used, their physical and chemical properties, the commercial products derived from them by thermal decomposition and methods of analysis. It deals also with factory construction and equipment and processes employed in the production of various by-products. Special chapters are given to the distillation of small and waste wood and the production of gas. W.S.J.

Dwarf and Slow-Growing Conifers.

BY MURRAY HORNIBROOK. *Country Life*, 1923. Price, 10s. 6d. net.

Contains careful, botanical descriptions of 460 dwarf conifers.

W.S.J.

Empire Forestry Journal, Vol. 2, No. 2, Dec., 1923.

London: The Empire Forestry Association, Imperial Institute. Price 4/- net.

The volume comprises, in addition to Editorial Notes and Miscellanea, Correspondence, Reviews, and Summary Report and Resolutions of the Empire Forestry Conference, 1923, articles on The British Empire Forestry Conference, Canadian Tour; Impressions of Canadian Forestry; Silviculture in Canada; Forest Fires in Canada; Canadian Insect Problems; Softwood Resources of Canada; Softwood Resources of the United States; Softwood Resources of Europe; Timber Trade in Europe; A Douglas Fir Plantation; Review of Indian Forest Management; India's Foreign Timber Trade; Suggestions for Marketing Tropical Timbers. W.S.J.

Forest Resources of the World.

BY ZON, RAPHAEL and SPARHAWK. *The Official Record*, Vol. II, No. 39, U.S. Dept. of Agriculture, Washington, D.C., 1923. pp. 1,000, coloured maps 16.

The authors show that the growth of timber throughout the world is 2-3rds of the amount consumed: statistics are given of extent and kind of forests, etc. W.S.J.

Forestry; Its Relation to Agriculture and the State.

BY J. J. MCLEOD. *Agric. Gaz. New South Wales*, 34: 426-430, 1923.

Points out that the natural forests of Australia consist chiefly of hardwoods and that the planting of conifers on an extensive scale would greatly enhance the value of Australian forests. The author submits a plan for such planting. W.S.J.

Forestry Commissioners; Fourth Annual Fourth Annual Report of the.

London: His Majesty's Stationery Office, 1924.

This report covers the period, Oct. 1, 1922—Sep. 30, 1923. The subject matter of the report is classified under the following main headings:—Forest Policy; Operations, Forest Year, 1922-23; Unemployment Relief; The British Empire Forestry Conference and the Imperial Economic Conference; Imports of Timber; Wood Manufacturers and Pulp of Wood. The report also contains a map showing Acquisition of Land.

The Forestry Commission has also issued a number of Bulletins, Leaflets, etc., of great value to those interested in Afforestation.

W.S.J.

Hornbeam (Carpinus Betulus L.) in Britain; The.

BY MILLER CHRISTY. *The Journal of Ecology*, Vol. XII, No. 1, January, 1924, pp. 39-94. Illustrated by two maps and seven photographs.

Possibly the most exhaustive and critical account of this tree in the English language. The subject is treated under the following heads:—I. Introductory Remarks; II, Classification and Nomenclature; III, Natural Range in Britain; IV, Characteristics in Britain; and V, Economic and Other Uses. The article ends with an extensive bibliography extending to four pages.

W.S.J.

Kiln Drying, Boxing and Crating, Gluing of Wood, Wood Properties and Uses, Demonstration Courses in.

U.S. Dept. of Agriculture Misc. Circ., 8, pp. 20, figs. 12, 1923.

A description of courses of study offered by the Forest Service at the Forest Products Laboratory, Madison, Wisconsin.

W.S.J.

Nigerian Timbers; Results of the Examination of.

Bulletin of the Imperial Institute, Vol. XXI, No. 3, 1923.

This article gives a brief description and results of Mechanical and Working Tests of six species of timbers, followed in each case by remarks on their main characteristics and suggested uses.

W.S.J.

Timbers; Their Structure and Identification.

BY W. S. JONES. Oxford: The Clarendon Press, 1924. Price, 15s.

The subject matter is divided into two parts. The first of these deals with the general structure of timbers and stresses characteristics of diagnostic importance. while the second comprises macroscopic and microscopic descriptions of a large number of timbers which are of economic value or are otherwise of interest. Two appendices are added, one dealing with Methods and Reagents and the other with Photomicrography as applied to timber study. The book is extensively illustrated by line drawings and photomicrographs.

C.B.J.

Wattle Bark from Ceylon.

Bulletin of the Imperial Institute, Vol. XXI, No. 3, 1923.

This article comprises the report of an enquiry by the Imperial Institute regarding the suitability of Ceylon for wattle growing (for tanning purposes). Of five samples of bark tested, four contained over 27 per cent. of tannin, and it is concluded that bark of similar quality should find a ready sale in the United Kingdom.

W.S.J.

LIVE STOCK.

Achondroplasia; The Significance of an—like Condition in Cattle.

F. A. E. Crew. *Proceedings of the Royal Society,* B. Vol. XCV, 1923.

The still-born monstrous " bulldog " calves of the Dexter breed present a condition very similar to achondroplasia in the human. The pathology of the condition is described and evidence is presented for the view that it is a consequence of defects in the pituitary. Its genetical significance is discussed, and it is suggested that the trouble is at least partly due to non-biological standards of excellence.

It is of interest that similar cases have been reported in Ayrshires, also that a certain breeder has successfully produced a Dexter-like animal from Shorthorn and Kerry matings and that in these animals the defect does not occur. J.A.F.R.

Brahma Cattle; " Double ears " in.

J. L. Lush. *Journal of Heredity,* Vol. XV, No. 2, 1924.

This peculiarity is a " thin flat piece of cartilage parallel to the main axis of the ear and projecting out of the back surface very much as the dorsal fin of a fish projects from its back. . . . It begins at or near the base of the ear, becomes larger further out and terminates abruptly, almost pointedly, about half-way between the base and the end of the ear." The author concludes that the statements of breeders agree at least permissibly well with the assumption that it is caused by a single dominant Medelian factor. It is probable that all the animals exhibiting this character on the ranches visited by Lush can be traced back to one bull, one of thirty-three imported from the Krishma Valley in India and that this original animal was heterozygous for the character. J.A.F.R.

Colours of Shorthorn Cattle.

R. W. Duck. *Journal of Heredity,* Vol. XIV, No. 2, 1923.

This work is based mainly on the examination of a large number of herd-book records, but also on the experimental results of Lloyd Jones and Evvard (see below). Duck is satisfied that white x white and red x red matings give nothing but whites and reds respectively. As regards red-and-white and roan markings, he accommodates his results in the following scheme. The homozygous red is represented as RR. the white as rr. In addition an extention factor E is postulated, which only produces an effect when the animal is heterozygous for red. The various phenotypes are represented.

Red	RREE	*White*	rrEE	*Roan*	RrEE	*Red-and-White*	Rree
	RREe		rrEe		RrEe		
	RRee		rree				

Animals possessing the constitution RrEe will sometimes be entered as roans, sometimes as reds-and-whites, as they will show a combination of both markings.

Among his important practical conclusions are:—

(1) Red x white matings will give the greatest proportion of roans, then roan x white. Red x roan, red-and-white x roan, roan x roan, will all give about 40 per cent roans.

(2) It seems impossible to secure pure-breeding roans.

(3) There is no correlation between colour pattern and sex in Shorthorns.

One of the most serious criticisms that can be advanced against this scheme is that it does not explain the occurrence of reds in white x white matings. The red animal often exhibits small areas of white, and it is doubtful on this ground as on others whether the scheme can be considered adequate.

Previous papers:—

Wilson—Mendelian characters among Shorthorn Cattle—*Sc. Proc. Roy. Dub. Soc.*, Vol. XI, N.S., No. 28, 1908.

Wentworth, E. U.—Colour in Shorthorn Cattle—*American Breeders' Magazine*, Vol. IV., No. 4, 1913.

Lloyd, Jones and Evvard—*Iowa Research Bulletin, No.* 30.

J.A.F.R.

Embryonic Pathology of Mammals; The problem of—with Observations upon the Intra-uterine Mortality of the Pig.

G. W. Corner. *American Journal of Anatomy*, Vol. XXXI, No. 5, 1923.

The author has observed in over 500 pregnant sows the exact state of the embryos at each state of pregnancy. It is found that even in healthy uteri about 10 per cent. of the fertilized ova do not segment, another 10 per cent. degenerate before implantation and 5 or 10 per cent. degenerate during implantation and the subsequent stages of pregnancy. It would appear that ova and embryos of fertile parents may suffer pathological change (presumably through internal defects of the germ-cells) in the midst of a healthy uterine environment.

C.f. the following papers by Hammond, which deal very fully with foetal degeneration:—

Hammond—*Journal of Agricultural Science*, 1914 and 1922.

J.A.F.R.

Genetics of the Multi-nippled Sheep.

W. E. Castle. *Journal of Heredity*, Vol. XV, No. 2, 1924.

In this paper is summarised breeding work carried out with sheep by Dr. Alexander Graham Bell for over thirty years. The principal object in view was the production of a race of sheep which should be multi-nippled and twin-bearing. Castle concludes that the character "superannuary nipples" is strongly inherited. Originally some of the ewes had an extra par and by selection the proportion of such individuals was largely increased. Six-nippled sheep were not produced by further selection, but were introduced into the flock by individuals with this character brought in from outside. The records also show that the particular grade of multi-nippled condition bourne by the parents is usually inherited by the offspring. Selection for a better degree of nipple development met with equal success. It appears that the normal low nipple number tends to dominate in crosses, but the possibility is indicated that the crossing of multi-nippled females of different breeds might lead to yet a higher grade in nipple number.

As regards twinning, the author concludes that heredity has had a relatively small influence on its occurrence in the Bell flock. His contention is that it is probable that the only genetic factors concerned in twinning

in sheep are those which affect the general vigour of the mother, causing multiple rather than single ovulations. While most geneticists would agree that this is precisely how they would expect most of the factors affecting fecundity to act, it cannot be a complete explanation, as it does not account sufficiently for the known variation in the proportion of twins as between breed and breed, or the records of individual flocks where large increases in the percentage of twins have been secured by selection. J.A.F.R.

Genetics of the Wensleydale Breed of Sheep.

1. The occurrence of black lambs—an examination of flock records.

F. W. Dry. *Journal of Genetics*, Vol. XIV, No. 2, 1924.

This study is based upon a large number of accurately kept flock-book records. The typical Wensleydale sheep has a white fleece, the skin of the face and ears being deep blue. About 15 per cent. of black lambs are born, and these blacks when mated together breed true. The author concludes that there is a single factor difference involved, the black individuals being the recessives and the white fleeced "blues" being the homo—or heterozygous dominants. It is held that the homozygous whites have faces which are paler in colour than those which are heterozygous, but these classes can only be distinguished with difficulty.

The recessive black in the Wensleydales may be compared with the blacks which occur in other breeds, *e.g.*, the Merino, Down sheep, etc., where the black also appears to be recessive. In the case of the black Welsh sheep, the Karakul (lamb's coat) and the Blackface, there are strong suggestions of a dominant black. This is discussed further in this volume. J.A.F.R.

Horse-rumped Cattle; Review of a Discussion at the Piedmontese Breeders' Conference (Mondovi, 1923).

E. Mascheroni. *International Review of the Science and Practice of Agriculture*, New Series, Vol. II, No. 1, 1924.

"Horse-rumped" cattle possess from birth a large rounded rump with well developed muscles and projecting buttocks, sometimes separated by a deep groove ending at the point of attachment of the tail. There is considerable variation. Calves of this type are to be distinguished by a thin, soft skin, well-developed muscles of shoulders, loins, croup and buttocks. The chest is sunk, abdomen narrow, legs somewhat short, hocks straight; there are serious defects of equilibrium and the vulva and teats of cows are always small. They occur in several breeds. "Horse-rumped" cattle are much superior to others from a butcher's point of view, and are in great demand; there are, however, serious objections to breeding them because of difficulties at parturition and in the rearing of calves. It is suggested that a Mendelian explanation should be sought.

The reviewer has seen in North Wales a bullock with a very similar conformation (probably a Welsh-Shorthorn cross), and believes that animals of this sort are sometimes called "hog-backed." It is possible that they are to be regarded as low-grade achondroflasts, c.f., Crew on "An Achondroplasia—like condition in Cattle," reviewed above. J.A.F.R.

Inheritance of "White Pattern" in Cattle.

Finquist and Boman. *Hereditas.* 1923.

The hypothesis is advanced that white pattern on the head of cattle is dependent on three factors. If the parents are homozygous with respect to

the character "no star" all the progeny are without the star and if heterozygous 25 per cent. of the progeny display the mark. The authors consider that the task of fixing colour as the Swedish breeders have tried to do is hopeless. J.A.F.R.

Jersey Cattle; An Hereditary Notch in the Ears of.

J. L. Lush. *Journal of Heredity*, Vol. XIII, No. 1, 1922.

The ears of animals with the notch appear when viewed from the front to have a piece neatly clipped out underneath. The outer end merges gradually into the slope of the ear, while the inner makes an acute angle with the lower edge, leaving a sharp projecting corner. There is considerable variation in the size of the notch in different animals. The evidence presented is not very detailed, but reasons are given for the assumption that this characteristic behaves as a simple Mendelian dominant. The author emphasises the important point that the study of non-economic factors in farm-stock is sure to lead to the discovery of some that will ultimately be found to serve as guides to the inheritance of more important ones. A similar notch in the ears of Welsh Black Cattle is described in an article in this volume. J.A.F.R.

Pure Breeds of Livestock; Mendelian Analysis of the.

II. The Duchess Family of Shorthorns as Bred by Thomas Bates.

Sewell Wright. *Journal of Heredity*, Vol. XIV, No. 9, 1924.

A description and analysis of the methods used by Bates, with special reference to the question of inbreeding. J.A.F.R.

Pure Breeds of Livestock; Mendelian Analysis of the.

I. Practical Breeding Methods in Terms of Modern Genetics.

Sewell Wright. *Journal of Heredity*, Vol. XIV, No. 8, 1923.

A valuable statement of breeding methods in scientific terms, with particular reference to inbreeding, and containing suggestions for methods of expressing inbreeding and relationship mathematically.

C.f. H. D. King, Studies on Inbreeding. *Journal of Experimental Zoology, Vols.* XXVI-XXVIII.

Sewell Wright. The Effects of Inbreeding and Cross-breeding on Guinea-Pigs. *U.S. Department of Agriculture Bulletins*, 1090 and 1121, 1922.

Sewell Wright. Coefficients of Inbreeding and Relationship. *American* Naturalist, Vol. LVI, 1922.

Sewell Wright. Systems of Mating. *Genetics*, Vol. VI. 1921.

Pearl. Studies on Inbreeding. *American Naturalist*, Vol. LI.

J.A.F.R.

Sheep; The "Gromet" Pattern in.

C. Wreidt. *Journal of Heredity*, Vol. XV, No. 3, 1924.

In the Western part of Norway sheep are often seen with a black design over the eyes, on the bridge of the nose and on the upper and under lips. The legs are black, except for grey stripes and a black stripe on the neck and breast sometimes occurs. The pattern is very similar, as is the sporadic appearance of the type in ordinary flocks to the "badger-face" pattern in Welsh sheep, the inheritance of which is now being studied at the University College Farm, Bangor. The author, from accounts furnished by two breeders who had bred the type pure, concludes that the pattern behaves as a simple Mendelian recessive. J.A.F.R.

Spotting on Holstein Cattle; The Inheritance of Degrees of.

L. C. DUNN, N. F. WEBB and M. SCHNIEDER. *Journal of Heredity,* Vol. XIV, No. 5, 1923.

This study is based upon an analysis of herd-book records. The degree of spotting is expressed as the proportion of black to the total area of the animal in profile. A white animal yould show 0 units. a black one 950 units. Those animals with 0—249 units of black were classified as "light," those with 250—699 as "medium," and 700—950 as "dark." The preliminary evidence presented indicates that differences in the amount of spotting are inherited and amenable to selection, that the darker grades are probably partially dominant over the lighter ones and that some degree of blending occurs, which it is suggested is possibly due to minor modifying factors whose expression together with that of the major factors is obscured by non-genetic variation.

It will be recalled that the results of Sewell-Wright (The relative importance of Heredity and Environment in determining the piebald pattern of guinea-pigs—*Proceedings of the National Academy of Sciences,* Vol. VI, 1920) showed that the degree of spotting in piebald guinea-pigs may vary widely within a family so closely inbred that it is practically a pure line.

J.A.F.R.

Intersexuality; Studies in.

Part I. A Peculiar Type of Developmental Intersexuality in the Male of Domesticated Mammals.

F. A. E. CREW. *Proceedings of the Royal Society,* B. Vol. XCV, 1923.

This study is based upon an examination of a large number of animals exhibiting striking abnormalities in the reproductive system. These take the form of an intimate mixture of male and female structures of the accessory sexual apparatus and are associated with some degree of imperfection of the external organs of generation. In most instances the history was that of an individual regarded as a female during the earlier part of its life which later assumed the secondary sexual characters and sexual behaviour of the male. In other cases the inperfection of the external genitalia was such that from the first the individual was recognised as abnormal. Cases examined included horses, cattle, sheep, pigs and goats. These cases formed a series which suggested that they were all grades of one and the same condition and the thesis is developed that they are males in which the differentiation of the sex-organisation is abnormal, the grade of abnormality in any particular case being dependent on the time-relations of the various factors associated with sex-differentiation. Those structures are most constantly affected which differentiate early in development, while in the case of secondary sexual characters which are not assumed till comparatively late in the life of the individual there is little or no departure from normality.

J.A.F.R.

The following papers mark a definite advance in our knowledge of the principles of heredity. While they are of great importance to all serious students of the subject, it is impossible to deal with them in a short review:—

(1) O. L. MOHR. A genetic and cytological analysis of a section deficiency involving four units of the x-chromosoma in Drosophla melanogaster.—*Zeitschroft für Inductive Abstammungs and Vererbuugslehre,* Vol. XXXII, 1923.

(2) (*a*) F. Aida. On the inheritance of colour in a fresh-water fish—Aplocheilus latipes Tammick and Schegel, with special reference to sex-linked inheritance—*Genetics,* VI, No. 6, 1921.

(*b*) O. Winge. A peculiar mode of inheritance and its cytological explanation. *Conptes rendus de Travaux du Laboratoire Carlsberg,* Vol. XIV, No. 17, 1922.

(*c*) O. Winge. One-sided masculine and sex-linked inheritance in Lebistes reticulatus. *Ibid,* Vol. XIV, No. 18, 1922.

(*d*) O. Winge. Crossing-over between X- and Y-chromosomas in Lebistes. *Ibid,* Vol. XIV, No. 20, 1923.

J.A.F.R.

POULTRY.

THE FOWL.

Inbreeding and Egg-Production.

Dr. F. A. Hays has contributed useful information on this subject, which is published by the *Massachusetts Agricultural Experiment Station.* He points out that while inbreeding for uniformity in colour, type, weight, etc., the breeder may be confronted by low vigour, low fertility and high mortality. The fact remains that close breeding has been used for one purpose—to secure uniformity. But the uniform individuals do not possess the vigour sought for. Inbreeding reduces variability in winter egg production only when the foundation stock is largely homozygous for factors for heavy egg yield (that is, tends to an increase of uniformity in this respect if the parents are both high in fecundity).

Sexual maturity seems to be retarded in many inbred pullets so that they are very slow in beginning to lay.

Winter egg yield shows a tendency to decline after the degree of inbreeding passes 25 per cent., but not necessarily so. A cumulative effect may be observed in succeeding generations. G.J.

The Moult.

Tom Newman. *Eggs.* 11/6/24.

For a bird to go through the moult without trouble, she must be in a good bodily condition. No greater mistake is made than attempting to throw a pullet into a moult by semi-starvation. Feed your birds normally, and if they do hang a bit add 5 per cent. linseed meal to the mash. There are some exceptional layers which will not moult and lay so late in the year that they are of little value as breeders next season. It is necessary to throw them into a moult, but the semi-starvation method is not advisable; often a complete change of diet and removal to another house will effect it.

G.J.

Pugnacity in Poultry.

W. Hicks. *Canadian Poultry Review.*

Some time ago attention was called to the danger of ultra-amiability in our poultry and that the suggestion to select the tamest and most docile birds is the sure way of success in making for degeneracy and possible extinction. Constitutional vigour is so important that it must be maintained. For the breeder who wants fertile eggs and vigorous chicks, irrespective of looks, let him first and foremost select the fighting cock and, what is more—after placing him in a pen with his hens—still keep his blood a-boiling and his glands secreting and exerting by keeping him in

full view of another fighting cock whom he hates. Select the best fighters as breeders, rejecting all who will not fight to the death if necessary.

G.J.

Stock Cockerels; The Rearing of.

H. H. HEMSLEY. *National Poultry Journal*, 1/8/24.

It is of the utmost importance that cockerels for stock purposes should be compelled to take the maximum amount of exercise. No greater mistake can be made than feeding them in like manner to birds prepared for table purposes. Stock cockerels should be made to scratch for every grain of food they consume after the age of six weeks. A bunch of cockerels will scratch just as heartily as hens, if they are made to do so. Too often the idea underlying stock cockerel rearing is to produce a fine upstanding, well-fleshed bird rather than one which handles like a cork, and is chockful of devil and vigour. G.J.

Undersized Chicks.

W. TIMMS. *National Poultry Journal*, 18/5/24.

In almost every large brood of chicks there are a few which do not grow as rapidly as the rest of the brood. I have traced many individuals back to their parent birds, but have found the birds which produced them also produce chicks which were in every way up to the standard. The cause is probably some trouble or other during incubation. Some time ago, when I had an extra large batch, I culled 45 of such chickens when three weeks old. These were treated in every way similar to the chicks in the main batch. Of the 45 only 26 were reared to maturity. Most of the pullets were two months older than their sisters when they commenced to lay, and none of them put up a good record in their pullet year. Such birds are uneconomical and should be disposed of as soon as they are observed. G.J.

INCUBATORS AND INCUBATION.

Hatching Duck Eggs.

OSCAR GRAY.

Poultry keepers often find the hatching of duck eggs successfully more difficult than hen eggs, particularly with incubators. The incubation of duck eggs is less understood. Different conditions must prevail. Select only well formed eggs. Period of incubation, 28 days in light breeds and about 30 days in heavy breeds. It is very essential to (*a*) maintain proper temperature, (*b*) provide sufficient moisture, (*c*) ensure additional means of providing increased ventilation during the latter stages of incubation. Temperature, when bulb of thermometer is about 1¼ inches above the eggs, 102°F first week, 103°F second and third week, 104°F the fourth week Carefully watch temperature about 15th day when embryo produces considerable heat. Moisture is of utmost importance—remember wild duck has her nest close to water and on marshy land. It can best be provided by two sponges of the size of a man's fist placed on the egg tray and kept constantly moist by being dipped night and morning in warm water. Additional ventilation should be provided from the 21st day to end of hatch. Incubators should be constructed with additional ventilators. During the last week large quantities of foul gasses are generated, and special means must be provided for their removal, otherwise percentage of dead in shell will increase. G.J.

LAYING, ETC.

Blood Purifier; Charcoal as.

WILL HOOLEY. *Poultry World*, 29/2/24.

The value of charcoal has not been fully appreciated by poultry-keepers. Its absorbent qualities are of immense importance. It aids digestion and is of considerable service in the treatment of intestinal complaints. Purity in pens are kept on the same ground, which sooner or later becomes tainted. In the natural state the fowl has fresh ground every day. The use of charcoal becomes obvious in present day poultry-keeping. Charcoal, through its absorbent qualities, is supposed to do inside the fowl what disinfectants do to the land. It absorbs gases and unhealthy substances. They are thus passed away without doing any harm. It can be fed as one of the ingredients in dry mash or provided in a vessel similarly to that used for grit, and the birds allowed to take what they require. If supplied in dry mash, 3½ lbs. is advocated to 43 lbs. of mash. Chicks as well as grown up fowls require it. G.J.

Eggs; Thin-Shelled.

TOM NEWMAN. *Eggs*, 11/6/24.

As a rule this state of affairs is due to the feeding being a little too stimulating for a pullet in full production. Where there is trouble of this sort, it is advisable to reduce the quantity of fish or meat meal for the time being. G.J.

Pigment; The Beak.

G. V. FOREST. *Feathered World*, 18/4/24.

One of the many signs of the layer is the fading beak pigment. This first of all fades from the vent then from the beak, commencing at the face and travelling down towards the point and finally the colour goes from the legs. G.J.

Poultry Food; Clover as.

Poultry World, 18/4/24.

Clover is rich in nitrogen, an element required for the formation of albumen (white of egg). It is also rich in lime -required for the shell. G.J.

Poultry Food; Skimmed Milk as.

Poultry World, 14/3/24.

Excellent food for all fowls. May be given as drink or mixed with other foods. It is claimed to be especially useful with white-fleshed birds it helps to improve the whiteness of the flesh, which is of importance to those who cater for the table poultry trade. G.J.

SOILS AND MANURES.

Ammonium Bicarbonate; Comparison of—with Ammonium Sulphate and Sodium Nitrate as a Fertiliser.

O. LEMMERMANN and E. ECKL. *Z. Pflanz. Düngung*, 1923, 2, B, 98-109.

Surface application of ammonium bicarbonate to potatoes before planting did not give as good results as when sodium nitrate or ammonium sulphate were applied in the same manner. The differences were not so apparent when the material was used on grain. It is not, however, considered desirable to use ammonium bicarbonate as a top dressing. R.W.

Atmospheric Nitrogen and the Dissolution of Organic Nitrogen by Certain Soil Bacteria; Biological Fixation of.

G. Truffaut. *Jardinage*, 1923, 10, 209.

A review of recent studies on the effect of partial sterilisation on the bacterial activities of soils. Attention is directed to the effectiveness of calcium sulphide as a partial sterilising agent. It has been found possible to increase the processes of ammonification and nitrogen fixation in soils provided they are not acid in reaction and contain sufficient nutrient materials for the bacteria involved. The addition of a small quantity of available nitrogen to a soil was found to result in a marked increase in nitrogen fixation. R.W.

Availability of Phosphates; Studies on the.

A. Demlon and P. Boischoff. *Compt. rend. Acad. Agr. France*, 1923, 9, 10.

Studies on the availability of phosphates are summarised, indicating that the presence of calcium carbonate in a soil has a tendency to decrease the solubility of phosphates and especially the natural phosphates. A marked effect from natural phosphates seems only to have been obtained on soils deficient in calcium carbonate. R.W.

Crop Production; Active Aluminium as a Factor Detrimental to.

P. S. Burgess and F. R. Pember. *Rhode Island Bull.*, 1923, No. 194.

Experiments were carried out which showed that acid soils contained active aluminium which exerted a specific detrimental effect. This was not correlated with excessive hydrogen-ion concentration. Application of either lime or soluble phosphate and the presence of large amounts of decomposing organic matter were efficient in counteracting the unfavourable effect of active aluminium on crops. R.W.

Fertiliser Experiments with Hot Composted Stable Manure.

O. Kron. *Mitt. Deut. Landw. Gesell.*, 1923, 38, 380-384.

The results of two years' experiments with wheat and of one year with potatoes indicate that the fertiliser value with special reference to the nitrogen content of artificially composted stable manure is about twice that of ordinary manure which has not been composted. It was noted that losses of nitrogen through composting were from 15 to 20 per cent., as compared with more than 30 per cent. with manure conserved by other methods. The use of a so-called manure silo for composting is discussed. R.W.

Fixation of Nitrogen by Activated Sludge.

C. L. Peck. *Engin. News Rec.*, 1923, 90, 487-489.

Experiments are reported in which it is shown that under certain conditions it is possible to fix atmospheric nitrogen by aeration in the presence of activated sludge. The amount of nitrogen so fixed was in some cases equal to 65 per cent. of the nitrogen present in the sewage. Th condition essential to fixation appears to be an environment favourable to the growth of Bacterium crenothrix. R.W.

Liquid Manure; Conservation of—with Acid Ammonium Sulphate.

H. Weissmann. *Z. Pflanz. Düngung*, 1923, 2, B, 356-358.

Acid ammonium sulphate may be used to prevent the loss of ammonia from liquid manure. R.W.

Natural Phosphate versus Acid Phosphate.

C. E. THORNE. *Ohio Exp. Station Bull.*, 1924, 9, Nos. 1-2.

The results of several comparative tests of raw rock phosphate and acid phosphate are summarised and indicate that whilst raw phosphate was generally used with profit, in practically every case the nett gain from acid phosphate was much greater. R.W.

Nitrate Formation in Soils; Effect of Time of Year on.

F. LOHNIS. *Centr. Bact.*, 1923, 58, 207-213.

It is concluded that variations in nitrification in soils are not entirely conditioned by environmental factors, but are seasonal functions of the nitrifying organisms.

Nitrogen for Crops; The Most Favourable Form of.

G. TRUFFAUT and N. BEYSSONOFF. *Compt. Rend.*, 1924.

Four year studies on the influence of different forms of nitrogen on various crops on slightly alkaline and slightly acid soils are reported. It was found that mixtures containing urea were superior to salts of ammonium, nitrates, cynanamide, and urea used alone. On acid soils best results were obtained with mixtures of urea and sodium nitrate, and on alkaline soils with mixtures of urea and ammonium sulphate. R.W.

Nodule Forming Bacteria; Effect of Acid Soils on.

O. C. BRYAN. *Soil Science*, 1923, 15, 37-40.

Studies at the University of Wisconsin on the effect of acid soils on the development of some important nodule forming bacteria are reported. Alfalfa (lucerne) bacteria were killed at pH 5.0, red clover bacteria at pH 4.5—4.7, and soy bean bacteria at pH 3.5—3.9. The critical hydrogen-ion concentration was found to be the same in soils as in pure cultures.
R.W.

Reversion of Acid Phosphate in Acid Soils.

T. D. HALL and J. C. VOGEL. *Soil Science*, 1923, 15, 367-369.

Studies conducted at the Potchefstroom Experimental Station in South Africa on the fate of superphosphate applied to acid soils with and without applications of limestone. The results showed that there was no actual benefit as far as the availability of the phosphate was concerned from mixing limestone with superphosphate or applying them to the soil separately.
R.W.

Soil Acidity; Distribution and Importance of.

A. GEHRING and F. SANDER. *Z. Pflanz. Düngung*, 1923, 2, B, 299-314.

A study of soil acidity and methods for its determination, together with results of cropping studies on soil of different acidities. The results in general show the extremely variable and as yet unexplained nature of soil acidity. It is tentatively concluded that the same or different crops can be differently influenced by different degrees of soil acidity and that different kinds of acidity act differently on crops under natural soil conditions. Many other phenomena enter as complicating factors. Caution is recommended in predicting the relation between plant growth and soil acidity. R.W.

Sour Soils; Modification of.

Rhode Island Station Bull., 1923, No. 193.

Hydrated calcic and magnesic limes were more effective in maintaining a neutral condition in soils than were the corresponding carbonates.

R.W.

VETERINARY SCIENCE.

Note on the Association of Tilletia Tritici with "Epileptiform Convulsions" in the Dog.

By J. Russell Greig, M.R.C.V.S., Professor of Medicine, Royal (Dick) Veterinary College, Edinburgh. *The British Mycological Society Transactions*, Vol. X, Parts I and II, pages 121 and 122, 26th September, 1924.

In three dogs suffering from convulsions, two of which died, numerous spores of "bunt" (Tilletia Tritici) were found in the faeces, throughout the alimentary tract, in the bile and urine, and also in the brain.

"Bunt" spores were found to be frequently present in the faeces of healthy dogs, but were not nearly so numerous as in the cases in question. Wheat straw used for bedding was suspected. N.B.

AGRICULTURAL BOOKS, 1923—4

The following list, prepared by the staff of the National Library of Wales, is a selection of the books on Agriculture published during the years 1923—1924 (Sept.). The list supplements THE HAND-LIST OF BOOKS ON AGRICUTLURE issued by the National Library, *second edition,* 1924, copies of which can be obtained on application to the Librarian, The National Library of Wales, Aberystwyth.

Anderson, OSCAR GUSTAF, and **Roth,** FREDERICK CARL.

Insecticides and fungicides: sprayings and dusting equipment; a laboratory manual with supplementary text material.
New York: Wiley. 1923.
pp. xvi, 350. ill., diags., front. ... ... 15s.

Bear, FIRMAN EDWARD. *Professor of Soils, Ohio State University.*

Soil Management.
New York: Wiley, 1924.
pp. vi, 268. ill., maps. Wiley Agricultural series. 10s.

Assumes the student has had courses in chemistry, botany, geology and physics.

Bewley, WILLIAM FLEMING.

Diseases of glasshouse plants.
London: Benn Bros., 1923.
pp. 208. pl., front.. diags., bibl. ... ... 12s.

The object of the writer is to bring before growers of glass-house plants the fundamental principles of disease control.

Bond, JAMES RYDING.

Farm implements and machinery.
London: Benn Bros., 1923.
pp. xvi, 282. ill. ... ... 35s.

Designed to assist the progressive farmer who wishes to understand the work and workings of farm implements, and how to select and use them.

Brenchley, WINIFRED ELSIE.

Manuring of grass land for hay.
London: Longmans, 1924.
pp. viii, 146. diags. Rothamsted Monographs on Agricultural Science .. .. 2s. 6d.

The results of experiments at Rothamsted, on heavy soil, the data being reduced to a semi-tabulated form.

Bruce, ISABELLA MACGILLAVRAY.

History of the Aberdeenshire shorthorn.
Aberdeen: "Aberdeen Press and Journal" Office, 1923.
pp. xii, 656. ports., pl. ... ... 21s.

Bruttini, ARTURO.

Uses of waste materials....1914—22.
London: P. S. King, 1923.
pp. xx, 368. ill., diags. International Institute of Agriculture, Rome ... ... 12s.

Details the measures taken to encourage the collection and conversion by manufacturing processes of waste material in view of their utilisation as food, feeding stuffs, fertilisers, etc.

Davis, JAMES RICHARD AINSWORTH.

The principles of agriculture.
London: Methuen, 1924.
pp. xiv, 262. ill., map., bibl. ... ... 7s.

A non-technical manual of ordinary farm routine.

Dyke, W.

Manures and fertilisers....ed. by T. W. Saunders.
London: Collingridge, [1924].
pp. 142. pl. ... ... 4s.

A popular manual on natural and artificial manures.

Edwardes, TICKNER.

Bee-keeping for all, a manual of honeycraft.
London: Methuen, 1923.
pp. viii, 136. ill., pl., diags. ... ... 3s. 6d.

A concise handbook on bee-craft based upon forty years of practical experience.

Ellis, E. T.

Insect pests.
London: Allen & Unwin, 1924.
pp. 158. ... ... 3s. 6d.

Deals concisely with the principal pests of flowers, fruit, vegetables, and forest trees, and gives simple remedies.

Enfield, R. R.

The agricultural crises, 1920—1923.
London: Longmans, 1924.
pp. xii, 212. diags. ... ... 10s. 6d.

An analysis of the causes and effects of the agricultural depression in England and the United States,

Fryer, PERCIVAL JOHN.

Successful spraying, and how to achieve it; a handbook for growers, nurserymen, horticulturalists, gardeners, and amateurs.
London: Benn Bros., 1923.
pp. 154. ill., diags., front. ... ... 7s. 6d.

Hendrick, JAMES.

The farmer's raw materials: air, water, soil and manure.
Edinburgh: W. Green and Son, 1923.
pp. xvi, 212. ill., front. ... ... 6s.

Textbook for the intermediate student.

Hoare, EDWARD WALLIS.

Veterinary materia medica and therapeutics...4th ed., ed. and rev. by J. Russell Greig.
London: Baillière, Tindall & Cox, 1924.
pp. xii, 664. bibl. ... ... 21s.

An introduction to veterinary therapeutics and pharmacology.

Hutcheson, THOMAS BARKESDALE, and **Wolfe,** THOMAS KENNERLY.

The production of field crops; a text book of agronomy.
New York: McGraw Hill Book Co., 1924.
pp. xvi, 500. ill., front., maps, bibl. ... 17s. 6d.

The first part of the book is devoted to principles underlying crops production, the second part to a discussion of individual crops.

Klimmer, MARTIN.

Scientific feeding of the domestic animals...transl. from the 3rd ed. by Paul Fischer...
London: Baillière, Tindall & Cox., 1923.
pp. x, 242. ill., diags. ... ... 18s.

Divided into two sections (*a*) Study of feeding stuffs: origin, characteristics, feeding value, etc. (*b*) Laws of feeding and nutrition.

Klimmer, MARTIN.

Veterinary hygiene, and the contagious diseases of domesticated animals...transl. from 3rd ed. by A. A. Liebold.
London: Baillière, Tindall & Cox., 1923.
pp. 432. ill., diags. ... ... 25s.

The sanitary cure of domestic animals. This and the preceding work were originally published as one work under the common title of Veterinary Hygiene.

Leitch, RENWICK HUTSON.

Dairy Farming.
Edinburgh: W. Green & Son, 1923.
pp. xii, 292. ill., pl., plans, diags. ... ... 6s.

An elementary introduction to dairy farming.

McHardy, D. N.

Modern farm machinery.
London: Methuen, 1924.
pp. xx, 236. ill., diags., front. ... ... 7s. 6d.

The construction and the working of each machine.

Malden, WALTER JAMES.

British sheep and shepherding.
London: Macdonald & Martin, [1923].
pp. [xiv], 240. ill., pl. ... ... 6s.

A practical handbook.

Malden, WALTER JAMES.

Grassland farming: pastures and leys.
London: E. Benn, 1924.
pp. xxiv, 314. ill., pl. ... ... 30s.

Connects everyday farming practice with the results of scientific research.

Perry, WILLIAM, *and others.*

Sheep farming in New Zealand.
Auckland: Whitcombe & Tombs, [1923].
pp. 162. pl., diags. New Zealand Practical Handbooks ... ... 2s. 6d.

Includes a concise description of each of the principal breeds of sheep reared in New Zealand.

Petherbridge, FREDERICK ROBERT.

Fungoid and insect pests of the farm. (*2nd ed.*).
Cambridge: University Press, 1923.
pp. viii, 178. ill., diags. Cambridge Farm Institute Ser. ... ... 6s.

The identification and treatment of the more common and destructive pests.

Punnett, REGINALD CRUNDALL.

Heredity in Poultry.
London: Macmillan, 1923.
pp. xii, 204. ill., pl., diags., bibl. ... ... 10s.

A summary of the results of twenty years experiments in connection with the genetical study of the fowl.

Reid, HAROLD AVERY.

The diseases of farm animals in New Zealand.
Auckland: Whitcombe & Tombs, 1923.
pp. xx, 568. ill., map. ... ... 30s.

Specially adapted to suit New Zealand conditions.

Robb, BYRON BURNETT, *and* **Behrends,** FREDERICK GARDNER.

Farm engineering: vol. 1, Farm mechanics.
New York: Wiley, 1924.
pp. xviii, 454. ill., diags. $2.50

Deals with mechanical jobs and with the handling of woodworking tools in repair and constructional work on an American farm.

Russell, *Sir* EDWARD JOHN.

Farm soil and its improvement.
London: Benn Bros., 1923.
pp. 126. pl., diags., map. ... ... 7s. 6d.

Written for the farmer and based upon experiments at Rothamsted.

Russell, *Sir* EDWARD JOHN, *and others.*

The micro-organisms of the soil.
London: Longmans, 1923.
pp. viii, 188. diags. Rothamsted Monographs on Agricultural Science. ... ... 7s. 6d.

The relationships of the population of living organisms in the soil to one another and to the surface vegetation.

Spencer, AUBREY JOHN.

The Agricultural Holdings Act, 1923, with explanatory notes and general forms... *7th ed.*
London: Stevens & Sons, 1924.
pp. xx, 216. ... ... 10s. 6d.

Tansley, ARTHUR GEORGE.

Practical plant ecology; a guide for beginners in field study of plant communities.
London: Allen & Unwin, 1923.
pp. 228. diags., bibl. ... ... 7s. 6d.

Wallace, ROBERT.

Farm live stock of Great Britain... *5th ed.*... by R.W., assisted by James A. Scott Watson.
Edinburgh: Oliver & Boyd, 1923.
pp. xx, 868. ill., pl., diags. ... ... 30s.

"An encyclopaedia of British farm stock," breeds and breeding, management and diseases.

Wardle, ROBERT ARNOLD, *and* **Buckle,** PHILIP.

The principles of insect control.
Manchester: Univ. Press, 1923.
pp. xvi, 296. ill., diags., bibl. Biological Ser. iii. 20s.

A résumé of recent literature concerning insect control methods.

Watson, JAMES ANDERSON, *and* **More,** JAMES A.

Agriculture; the science and practice of British farming.
Edinburgh: Oliver & Boyd, 1924.
pp. xii, 656. ill., pl., diags. ... ... 15s.

Primarily intended for the use of students attending courses of agriculture in Universities, Colleges, and Farm Institutes.

Wood, THOMAS BARLOW.

Animal nutrition.
London: W. B. Clive, 1924.
pp. viii, 226. ... ... 4s. 6d.

The utilization of the produce of the soil for the feeding of animals.

Wood, THOMAS BARLOW.

The chemistry of crop production. *2nd ed.*
London: W. B. Clive, 1924.
pp. [viii], 194. maps. ... ... 4s. 6d.

A study of the scientific principles of crop production. Assumes an elementary knowledge of chemistry.

Wooldridge, GEORGE HENRY, *editor.*

Encyclopaedia of veterinary medicine, surgery and obstetrics.
London: Henry Frowde, 1923.
2 vols. pl., front., ill. ... ... 63s. each vol.

V. 1. Veterinary medicine. V. 2. Surgery and obstetrics.

Wyndham, HUGH ARCHIBALD.

The early history of the thoroughbred horse in South Africa.
London: Milford, 1924.
pp. xx, 276. pl. ... ... 12s. 6d.

The history of the half-bred horse in South Africa up to about 1870.

(*To be continued*).

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CONTENTS.

HUMAN MOTIVES IN FARMING.

By A. W. Ashby, Hon. M.A.,

University College, Aberystwyth.

Farming presents many aspects to even a superficial observer. Its primary aspect perhaps is that of a process of producing crops or livestock for human food. Its second chief aspect is that of a business of selling these things and of buying the articles required to produce them. But in these two sets of processes the farmer has many functions. The generality of farmers are employers and organisers of labour, workers themselves, business men and, it may be, craftsmen or artists all combined. Fortunately, for the farmer himself all these things are summed up in his functions as craftsman and business man. He can even keep these two functions in their place according to human values. It is as a man that the farmer has to be approached if he is to be induced to recognise that any of the many branches of scientific knowledge may be of use to him. Even when he seeks knowledge from science or the sciences it is often as a man rather than as a farmer.

There are many people who will deny this. They say that the strongest appeal, some say the only appeal, is made to the farmer through " the economic motive." Yet no man has a single motive that is active all the time and everywhere even within the sphere of business life and activity. The farmer notoriously mixes his business activity with his personal life: they merge imperceptibly one into the other. This is commonly expressed in the phrase that " farming is not a business but a life." And if we want to know how or why a farmer acts in a certain way or how to induce him to act in a certain way, we have to enquire why men act, and especially why men act as they do when they live in the sort of social environment and general circumstances in which farmers live.

The "Economic Motive."

It is quite generally assumed that political economists believe in an "economic man," and those who believe in the potency of "the economic motive" sometimes base their authority on economists. Such conceptions, however, are derived rather from the critics of political economy than from the political economists themselves. Some popular conceptions of the "economic man" are:—

> "A being whose sole motives and incentives to action are self-interest and the desire to obtain the greatest possible material gain with the least possible effort."
>
> Or, "the economic man is one who in his economic relations is moved only by regard to his own material interests."

These simple explanations of human conduct, even in economic activity, have never been accepted by economists. Perhaps one of the statements that comes nearest in simplicity is that of Cairnes, who gives as "paramount mental principles" of the basis of political economy "the general desire for physical well-being and for wealth as the means of obtaining it, the intellectual power of judging the efficiency of means to an end, along with the inclination to reach our ends by the easiest and shortest means." These, says Cairnes, are "mental facts from which result the desire to obtain wealth at the least possible sacrifice."

Even when economists have based their thought on any such simple conceptions of human nature, they have generally limited the application of them to what they call *contractual* relations, i.e., relations between person and person on which contracts of a legal nature arise. Thus one economist: "In buying and selling, in agreeing to pay or to accept a certain rate of wages, in letting and hiring, in lending and borrowing, the average man aims at making as good a bargain for himself as he can." This chiefly applies to what may be called commercial relations. It has little direct connection with production, especially if conducted under a small-scale organisation. And it is obvious that a great many farmers' activities have to do with things rather than persons. In farming many motives lead to activity.

The Psychological Basis of Activity.

A motive is that which moves or causes one to act. In this sense it will be most readily understood as impulse. But in ethical usage a "motive" is restricted to the end or purpose which moves the will. Thus a motive in this sense may lead to relative inactivity,

as when a desire for an easy life leads the owner-occupier of a farm to run his farm on the easiest lines without any regard to the rules of good husbandry. However, motives as causes of activity are more important, and if the desire for profit or the greatest possible material gain for the least possible effort is not the only or the chief motive actuating farmers it is desirable to enquire what other impulses may be.

Here we turn from the economists to the psychologists, for although farming is too complex an activity to allow of application of simple psychological principles to the persons who follow it, the studies of psychologists will be of assistance. Psychologists deal primarily with instincts and emotions as causes of activity. Of these some are primarily of personal importance, but all have a social significance, and some are of direct importance in the economic sphere of activity and of social relations. Amongst the last group the following may be given as of primary importance in the consideration of farmers' motives.[1]

1. Fear.
2. Parental instinct.
3. The instinct of acquisition.
4. The instinct of construction.
5. Emulation and rivalry (or competition).

Of course there is no instinct, emotion, sentiment or habit which may play in the mind of human kind which may not equally play in the mind of a farmer. We are here concerned with those which appear to be most common, and most potent, in the minds of men following that industry under the conditions and in the environment in which it is usually carried on.

Fear (or, as Macdougall names the phenomenon, the instinct of flight and the emotion of fear) is one of the simplest and strongest motives operating amongst farmers. In the form of fear of privation, if not of starvation, it acts especially on a number of very small farmers who live near the margin of subsistence. They fear often not only privation but also loss of social status for themselves or their families. Although this motive is not the chief one, except amongst a minority of farmers, its effects are important. The characteristics of work done under the emotion of fear are hurriedness and lack of consideration of method or of means to an end.

1 Some psychologists label an instinct by one name and its accompanying emotion by another. In common parlance, however, an instinct and its accompanying emotion are usually known by one term and this usage will be followed here when necessary.

It has in it some of the qualities of flight. When this motive has been strong, and then weakened by the removal of its cause, tendency to slackness of work appears unless other motives arise. Little appeal can be made unless other motives can be aroused. But fear in a less intense form is also an element in the motives of many other farmers, as in the case of those who are afraid of weather or movements in prices. In this more complex form it is susceptible to check by reason and by the rise of other motives.

The *parental instinct* in a strong and simple form is also a powerful motive in many farmers. When they have passed the economic stage in which fear is a potent motive this is often one which takes its place. Some Agricultural Organisers know this, for they find the argument: "It will be good for the boys," or "It will interest the boys," very useful when ground is wanted for an experiment or an innovation in method is suggested. The type of action to which this instinct leads varies to a considerable extent. It sometimes creates, with custom, tradition or ingrained habits, a position in which sons or daughters, sometimes of adult age, are still regarded as children in respect of responsibilities—in fact, to a partial form of patriarchy.[2] In some men it leads to parsimonious saving for children, especially if they are regarded as weak in any particular; and in others it leads to careful enterprise and intelligent progress for the intellectual as well as financial benefit of children, especially sons. It is probable that the direct effect of the parental instinct in economic conditions and relations is more prominent in farming, especially in small-farm areas, than in any other industry. Here the relation of parent and child is closer and continued longer than in almost any other social environment. And so long as it does not develop until willingly or unwillingly there is a state of dependence of the adult young on the failing old generation, with the latter retaining all authority and all economic means, the industrial effect is good. Although the parental instinct is found active in the great majority of farmers with families it is only in a small proportion that it is the predominant economic motive.

Perhaps most people would say that the *instinct of acquisition* is the predominant motive amongst farmers as an industrial group. In the widest sense in which the instinct could be regarded this would

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[2] The following is a description by Leplay of the effects of the patriarchial regime: "In all matters relating to economic action or to social life it shows greater attachment to the past than concern for the future. Obedience is the keynote rather than initiation. The family group tends to arrest the enterprise which would otherwise characterise the custom of the more independent members of the family in a somewhat freer atmosphere."

be true. But care should be taken so as not to confuse the instinct of acquisition as such with the desire to acquire wealth as a means to an end. The latter, for instance, might be an expression of the parental instinct—the end being the financial safety of the children. In the narrower sense, of acquisition merely for the sake of possession of the thing acquired, this instinct is very potent in a number of farmers. "Miserly" would be a common description of their characters, but the instinct is applied to the acquisition of many things besides money. It applies, in some instances, particularly to land. Here the instinct of acquisition may be mixed with some idea of or desire for economic safety. In some cases, however, it is satisfied with the mere pride of possession. It also applies in some instances to acquisition of machinery—as when that is bought, put in the barn and then looked at with satisfaction, but unused. It applies occasionally to stock, as when a sire is bought at a high price and used without any very definite idea of its use as a means to improvement of flock or herd and with very little thought of its suitability for that purpose. Temporary pride of possession and use is sufficient satisfaction for the price which is paid. On the whole the desire to acquire money or certain other things, for the sake of possessing them and not as means to ends, appears to be much more common than casual observers would suppose.

The *instinct of construction* can be regarded in two senses. In the narrower sense of mechanical or logical construction it is not common amongst farmers. In the wider sense of the instinct for making things—the things which the farmer makes in the range of his work or business—*the instinct of making or construction* is very potent amongst farmers. It is found in many and it is found in a strong and simple form. There are some farmers in whom it is stronger than the desire to acquire wealth, either for its own sake or as a means to ends. When the working of this instinct is accompanied by the possibility of acquiring wealth, or at least economic security, the majority of farmers, as farmers, are happy. But there are some who will suffer reduction of profits rather than fail to maintain their standard of farming, i.e., the weight, quality or appearance of their crops; or the type and weight (or form and appearance) of their stock. The observer may be inclined on occasions to interpret the effects of this instinct as the result of ingrained habit or tradition, but he will frequently be wrong. In individual cases this instinct is strong enough to lead to definite attempts at aesthetic expression in the plastic form of crops and stock. When it does not go so far, the instinct frequently finds

expression in what might be generally called "craftsman's ideals and efforts." These may result in higher earnings or profits, but they are not necessarily undertaken with that direct end in view. The free expression of the instinct of making things is one of the important conditions of happiness for many farmers. It is an instinct which can be used and should be fostered by persons concerned with agricultural improvement. There are people who would supplant this instinct by the desire for wealth, but if successful they might not leave a happier even if they left a richer farming class. If agricultural education or research could offer farmers methods which would render more free expression of this instinct consonant with lower costs or greater profits it would contribute a real service.

There is some argument amongst psychologists as to whether *emulation*, the *spirit of rivalry* and the *spirit of competition* should be regarded as instinctive. But whether instinctive or not, the desire to emulate, to excel or to get the better of others is a strong human motive. It will not, however, be found in all farmers, for there are some who placidly accept the idea that their standard of farming, or their stock, can never be as good as that of one or more of their neighbours. Indeed, there are some farmers in whom the *instinct of self-abasement*, as it is known by Macdougall, will be found. They will abase themselves as farmers, even when they would not do so in purely personal relations, as in their chapels or in local politics. On the other hand, when mixed with the *instinct of self-assertion* the spirit of rivalry is a powerful motive in a great number of farmers. The effects of this instinct and desire will generally be known as ambition; and it appears that this must be a strong moving force amongst Welsh farmers. Amongst over 800 persons farming in Wales whose origin has been recently examined, about 11 per cent. were sons of farm workers, 7½ per cent. sons of other manual workers, and nearly 6 per cent. sons of artisans. Of this group of farmers, only 64 per cent. were sons of farmers engaged only on the parental farm, while 23 per cent. of them had worked as hired farm workers, and nearly 7 per cent. had been engaged in other manual work. Even amongst a group of farmers each paying £150 or more per annum in rent over 10 per cent. had previously been farm workers or had been engaged in other manual occupations. Many of these would be moved by ambition in its personal form quite as much as by the desire to acquire wealth. Indeed, we are frequently in danger of confusing real personal ambition with the desire for wealth as such. The amount of yearly income or wealth is sometimes the only criterion of success amongst men of business,

and even amongst other men. It is the criterion most readily applied and understood. Consequently some men desire wealth as a proof of their success as much as they desire it for its own sake. The desire to excel also appears in other forms. There is sometimes definite rivalry or competition between two or more farmers in the production of a bunch of stock or an animal of some kind. This is often stimulated by local exhibitions. The desire to get the better of neighbours or others sometimes appears in connection with local competitions and shows, but it appears in a stronger form in connection with the larger exhibitions. There are also instances in which the desire to excel appears in a debased form, as when it is proclaimed by a seller that an animal fetched a higher price than that for which it was actually sold. Cases in which high (but nominal) prices are fixed with dealers merely for the sake of impressing neighbours are not unknown.

There are other instincts more powerful than some of these, but we have been concerned only with those which are most likely to be powerful motives in the relations with men and things which the farmer has as a farmer. It must, however, be said that the instinctive impulses mentioned above will be expressed through acquired habits of thought and action and may be modified by these. "An acquired mode of activity becomes by repetition habitual, and the more frequently it is repeated the more powerful becomes the habit as a source of impulse or motive power."[3] As is known, habits are strong in many farmers. They are not, however, in many instances strong enough to hold back ambition, to stop the instinct for making things expressing itself in new forms, or to prevent the powerful parental instinct from impelling the adoption of new ideas.

General Economic Motives.

It is said that "the business side of life is that in which man's conduct is most deliberate and in which he most often reckons up the advantages and disadvantages of any particular action before he shapes his course." The truth contained in this statement may be easily exaggerated, especially in respect of farmers in whom acquired habit is strong, yet doubtless the thinking which it indicates should be encouraged. As some persons may prefer to think of motives in a more ethical sense than that in which they have been treated above, the ethical motives (i.e., the ends or purposes which move the

3 Macdougall: *Social Psychology*, p. 43.

will) sometimes said to be most effective in the economic sphere of life should be stated. These are:—

Desire of economic advantage or fear of economic need.
Fear of punishment or hope of reward.
Feeling of honour or striving for recognition (or. desire for moral approbation and fear of shame and contempt).
Need of occupation and pleasure of activity.

It will be noticed that these motives are somewhat similar to the instincts mentioned above, but that they are more intellectualised in form. It is only necessary to add that these motives. even the first, are not necessarily selfish or primarily self-regarding. Desire of economic advantage may be, and frequently is, the desire of economic advantage for a family rather than for the individual. and to the latter the following of that desire may be an unselfish action, willed after the consideration of alternatives.

Although we cannot determine the ends for which farmers will work, we may be able to assist them in the adoption or adaptation of means to those ends. But before we can adopt or modify their ends and purposes to social aims we have to understand their predominant instincts, their habits, and their intellectualised motives. And we shall be better able to assist them to adapt means to ends if we can understand a little of the prime forces which move them.

THE SOCIAL ORIGIN OF WELSH FARMERS.

BY A. W. ASHBY. HON. M.A., AND J. MORGAN JONES. B.A.,
University College. Aberystwyth.

Introduction.

"While it is the purpose of agricultural production to satisfy human wants, and man is rightly considered as the end in view in the production of all economic goods. it is also true that human brawn and human brain are so important in giving direction to the other factors (land and capital) that man may easily be counted the most important of the three factors of production. Whatever affects man as an agent in agricultural production seriously affects the results of this basic industry."[1]

It was with these principles in mind that an investigation of the social origin of Welsh farmers was started a year ago. There are problems in the sphere of agricultural economics which arise on

[1] Taylor: Agricultural Economics, p. 102.

individual farms or groups of farms and may be studied there. Other problems arising in markets and affecting farms may be studied in markets and on farms. Still others arise in the whole national organisation of industry and social life. The results of maladjustment in any of these spheres are to be found both in the farm unit on one hand and in the whole social organisation on the other hand. If the maladjustment arises in or through the human factor in the industry its results are quickly found both on the farm and in society. The problems connected with the human factor in agriculture, however, have notoriously been difficult to measure. Human misfits and maladjustments may be known in individual cases, and sometimes the effect of these is striking. On the frequency of the occurrence of individual cases few people have any ideas, or anything more than a facility for intelligent guessing. Thus it is often urged that there are persons in other occupations who would like to become or ought to become farmers. It is also sometimes said that there are persons in control of land who, by reason of innate personal characteristics, of habit, or of training, ought not to possess such control. Of the validity of the first proposition there can be no adequate measurement,[2] but there may be a measurement of the proportion of the present farmers who have taken to farming after following another occupation. A fairly adequate measure of the frequency of occurrence of misfits actually within the industry is not impossible and some reason for misfits may be discovered. The investigation of the origin of Welsh farmers was partly directed to the measurement of these two sets of phenomena. But as the supply of capital for the industry comes through the human factor and mainly directly through the personnel of the farming group, any knowledge of the origin of personnel will contribute to knowledge of the origin and the conditions of supply of capital.

Knowledge of the origins of the persons becoming or desiring to become farmers; and knowledge of the origins and conditions of supply of capital; must affect all considerations of the size of farms, or "the economic unit" in the industry. The question of the proper size of farms, or of the proper frequency for access to control of land may be regarded primarily as a social problem. It is, however, not always or even necessarily or primarily of that character. While it is true that the products of agriculture must be designed to meet human needs, it is also true that the processes and organisation of production in agriculture, too, must be so designed to meet other

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[2] The practical impossibility of any measurement of the number of persons who wish to become farmers was shown by some enquiries amongst soldiers in France at the end of the War.

human needs. And within this social problem of the "economic unit" or the size of farms there are many problems of farm management. Some of these are technical in character, or may be treated as problems in industrial economics. Confining consideration to the more human aspects, the best supply of information on the science of agriculture or art of farming will be of little use unless persons in control of land are capable of applying it and willing to make use of it. Or the most willing and capable cultivators may be unable to make use of information if the capital required in the process is unobtainable. In the narrower sphere of farm management, as such, there are also problems which spring from human sources. On the small farm one of the chief conditions of success may be the willingness or the capacity of the cultivator to apply himself to manual work with intelligence and diligence. When the size of the farm, or the business, requires a labour staff of three or four persons, the conditions of success begin to change. Then more is required of the farmer in the way of direction and organisation of the work of others and of the organisation and use of capital and the equipment which may be procurable, than in the way of application of his own manual labuor. Probably success is then more dependent upon marketing and the whole range of "business" transactions as distinct from manual work. If this is the case, as there can be little doubt, then the problems of the "economic unit," the "farming" or "social ladder," the problem of capital or credit, become to some extent unified in one problem of the human factor in the industry: the origin of farmers, the training they receive, the traditions they receive through their social inheritance, the habits they form, and the capital they inherit or are enabled to save. Some measurement of these problems has been obtained in the investigation of the social origin of farmers in Wales.

Methods of Investigation.

The data here dealt with were collected by the aid of local correspondents in the winter of 1924—25.[3] They cover sections of each of eleven counties in Wales and Monmouth, the counties for which no data were obtained being Flint and Merioneth. The sections vary in size, and in the number of farmers contained, but there is no evidence of a selection of farmers for whom details were recorded. The local correspondents were recommended to take a whole parish and endeavour to record details for every farm, leaving out only the farmers whose origins could not be ascertained.

[3] See note at end, p. 35.

The items to be recorded were: (1) the size of farm occupied, (2) the rent or rental value of the farm, (3) the quality of farming, (4) the previous occupation of the farmer, if any, (5) the occupation of the present farmer's father, (6) the occupation of the farmer's grandfather. Some of these items require comment.

A *farmer* was defined as "a person who gains a livelihood by farming land, whether the farm be large or small." Other persons, such as miners, or tradesmen who obtain the major part of their livelihood from some other occupation, were not intended to be recorded as farmers, and correspondents were instructed accordingly. *The size of farm* was recorded by stating acreage of land in three categories, viz., Pasture, Arable and Rough Grazings (*mynydd a thir grug a ddefnyddir fel tir pori*), or any one or more of these as might be required. But as the quality of land varies in such wide degrees in different parts of Wales, and as even the quality of land in any of the above categories may vary widely, no classification of farms on the basis of area has been attempted. The rent or rental value is a better indication of the size of the business which is based upon the land than the mere area, and consequently classification by size of business has been based on rental value. Moreover, had area been used as a basis of classification, the difficult question of the ratio of value of rough grazings, *ffridd*, and improved pasture would have at once arisen. In some of the districts from which records were obtained rough grazings are not common. In others nearly every holding has rough grazings attached. The rental value then affords the best, though by no means a perfect, measure of comparative productivity of land.

The rent of the farm required was the actual rent paid. In some cases, however, farms are occupied by owners. The "rental value" then entered was sometimes the rent paid before purchase, especially when purchase had been recent, and in other cases the "gross estimated rental" as used for rating purposes has been recorded. Some other actual rentals were not obtainable for other reasons and the "gross estimated rental" has then been stated. The rental values thus obtained have been used as a basis for classification of farms. But it will be recognised that such rental values have not all the same validity as a basis of classification. The gross estimated rental as ascertained for rating purposes may be lower than the actual rent paid; and in extreme cases by as much as 25 per cent. Consequently it may be that a farm for which this rental value has been recorded would rise into a higher classification if the actual rent could be ascertained. This complication, however, does not appear to be very frequent.

On the *quality of farming* it was intended to obtain a judgment whether the quality was "good," "medium," or "poor," and correspondents were instructed not to attempt to record finer distinctions of judgment. Moreover, the standard to be taken for these judgments was the quality of the farming of the district and not any theoretical standard of good farming or even the quality of farming in other districts where agricultural conditions might not be the same. The reference to quality of farming was to be to "the quality of the farming of each farm in comparison with the general standard of farming in the district. The chief criteria of quality of farming should be the quantity and quality of crops grown and of stock kept. Moreover, each recorder was asked "to obtain the judgment, and if possible, the concurrence, of another person in grading the quality of farming" on the farms recorded in his district. Although such judgments thus made and recorded are open to error, every effort was made to reduce the error as much as possible. Recorders universally restricted judgments to the three grades of quality and to the terms by which they are described; and there is evidence that they used the standards of their own districts rather than theoretical or outside standards in the fact that 46 per cent. of farming was graded as "good," 41 per cent. as "medium," and 13 per cent. as "poor." There are some local variations from this average, but they are unimportant. On the whole it appears that judgments of quality of farming have been fairly and carefully made and recorded.

As regards the *previous occupation* of the farmer, the intention was to record whether the present cultivator had any other occupation since reaching manhood at the age of, say, 20 or 21 years. The information required was whether or not the present farmer had for any important part of his life another occupation or business. Where the farmer concerned had been in another occupation for two or three years of his youth only, the fact was not entered. It was, however, particularly requested that if the farmer had been a hired farm servant for any considerable period of his life, the fact should be recorded. The previous occupations of living farmers thus recorded covered a wide range of occupations, from the professions downwards. The same instructions were given as regards the record of occupations of fathers and grandfathers of the present farmers, except that where the person concerned had at one time been a farmer and at another time in another occupation or business he should be recorded as a farmer. Again, the range of occupations of fathers and grandfathers of the present farmers actually recorded

was very varied and extensive. For the sake of simplicity, however, the classification of occupations has been limited to (1) "farmer's son," (2) farm worker, (3) other manual workers or labourers, (4) artizans, (5) other occupations; (*a*) requiring capital, (*b*) not requiring capital. The reference to capital here is to its requirement for the purpose of the occupation and not to its possession. Obviously, there are dangers in attempting to record whether or not capital was previously owned by persons covered by such a widespread enquiry, and no enquiries were made in respect of this item. In connection with the record of previous occupation, a "farmer's son" is defined as a son of a farmer who had no occupation other than that of a resident or worker on the family holding. But both "farmer" and "farmer's son" must be construed to cover, in individual cases, daughters also, for in covering whole groups of occupiers of farms, widows or other women in control have been recorded.

General Results.

The records thus obtained in some degree cover conditions during a quarter of a century or more, for they include farmers who have recently begun a farming career with others who may have spent up to 40 years in the industry, but that is not to suggest that had an investigation been made, say in 1906, the results would have been the same. Changes in the total number of farmers in Wales have occurred during the last 50 years. There was a decrease of about 3,000, or nearly 8 per cent., between 1871 and 1881, while numbers remained fairly steady until 1911, when an increase of about 3,000, or 8 per cent., occurred in the next decade. The later increase appears to be partly due to legal and social measures to increase the number of small holdings.[4] The mere fact of the increase in numbers would not point to any change in the social origin of farmers in recent years, but the increase together with known social measures point to the assumption that the farming class is more fluid and recruited from more varied sources than it was two decades ago. And had an investigation been made between 1901 and 1911, when the total number of farmers was quite steady, it is probable that the farming

[4] Since 1908 the total number of small holdings provided by Small Holdings Authorities (Counties and County Boroughs) in the Principality is about 2,250. Of these some 934 were provided under the Act of 1908, and the remainder under the Land Settlement Act. But, as will be shown later (p. 19), this has not caused an increase in the total number of "agricultural holdings" as given by the *Agricultural Returns.* It is not known how many of the statutory small holders were farm workers, farmers' sons, or engaged in other occupations; but of 4,470 *applicants* for holdings between 1908 and 1914, only 989, or 22 per cent. were described as farm workers.

class would have been shown to be more fixed than the results of the present study indicate. However, even when the total number of farmers was steady the class was a fluid one, recruiting members from outside and sending members or their progeny to other occupations.

The recorders succeeded in recording the items of previous occupation of the present farmer and the occupation of the farmer's father in 834 cases and every item of the investigation in 771 cases. The latter group will be mainly dealt with here, but in certain items comparison will be made with the results of the larger group. These are not large samples, for the larger group represents only 2.04 per cent. and the smaller group only 1.9 per cent. of the total number of farmers. Nevertheless, the samples are adequate for present purposes, and they are as large as it might reasonably have been expected to obtain. And it is reassuring that in some respects there is no appreciable difference between the results shown by the larger and by the smaller sample. In the case of classification of holdings by rentals the proportions in each group are almost identical.

Proportions of Holdings in Rental Groups.

Rental Groups (Rent or Gross Estimated Rental).	Larger Group (834 Farmers).		Smaller Group (771 Farmers).	
	Number.	Per cent.	Number.	Per cent.
1. £30 and under ...	194	23.26	177	22.95
2. £31—£49 ...	155	18.58	144	18.67
3. £50—£99 ...	322	38.61	303	39.29
4. £100—£149 ...	104	12.39	95	12.32
5. £150 and over ...	59	7.07	52	6.74
Total ...	834	100.00	771	100.00

The larger group is inclusive of the smaller, but the results in the smaller group show no important deviation from those of the larger group in respect of classification of holdings. It is unfortunate that there are no means of ascertaining to what degree this distribution of farms by rentals corresponds with the general distribution. Even if classification were made by area this would be the case, for the *Agricultural Returns* give numbers of "holdings" as units of land tenure and not as units of farming businesses.[5]

[5] The numbers of "agricultural holdings" as given by the *Agricultural Returns* at various dates are given below. These show an actual decrease between 1911 and 1921, the period for which the *Census* shows an increase in the number of farmers. But a decrease in the number of "agricultural holdings" as units of land tenure may be quite consistent with an increase in the number of farmers. A further decrease in the number of agricultural holdings is shown for the period 1921-24. It is somewhat striking that the creation of over 2,200 statutory small holdings since 1908 has not sufficed to maintain the total number of "agricultural holdings." (*See footnote opposite*).

Previous Occupations of Farmers.

As regards the previous occupations of the present members of the farming class the two samples again show approximately equal results.

Proportions of Farmers in Previous Occupations.

Previous Occupation of Present Farmer.	Larger Group (834 Farmers).		Smaller Group (771 Farmers).	
	Number.	Per cent.	Number.	Per cent.
Farmer's Son ...	537	64.38	510	66.14
Hired Farm Worker .	186	22.30	165	21.40
Other Manual Worker	56	6.71	49	6.35
Artizan ...	29	3.48	24	3.11
Other Occupations Requiring Capital ..	15	1.80	13	1.68
Not requiring Capital ...	11	1.31	10	1.29
Total ...	834	100.00	771	100.00

The further analysis of the previous occupations of farmers can thus be confined to the smaller group of farmers for whom all other items, such as quality of farming, etc., were recorded.

The general results above show that some two-thirds of the present race of farmers have never had any occupation other than that of residents or workers on the parental farm. As most of the farms are small, less than 20 per cent. of them being over £100 in rental value, the great majority have been manual workers on the parental farm. Over 20 per cent. have been hired farm workers, but one-third of these are actually sons of occupiers of farms which are too small to provide employment for all the members of the family. Thus about 88 per cent. of the present class of farmers have been in a farming occupation during the whole, or practically the whole of their working lives; and only about 12 per cent. have had other occupations. Of the latter, one-half have been labourers or unskilled workers in other industries and trades. But the most surprising result is that so few farmers in Wales are recruited from the "trades and professions." especially from those in which capital is required.

Number of Agricultural Holdings in Wales and Monmouthshire.

	1907.	1911.	1921.	1924.
Above 1 and not exceeding 5 acres ...	11,086	11,052	9,927	8,966
Above 5 and not exceeding 50 acres ..	34,284	34,437	34,553	33,558
Above 50 and not exceeding 300 acres ...	19,507	19,412	18,626	18,543
Above 300 acres	453	424	327	326
TOTAL	65,330	65,325	63,433	61,393

SUMMARY TABLE I.

Showing the Percentage of Farmers of Different Previous Occupation in each Rent Group.

Rent Group.	Total Number.	% of Total.	Base for Proportion.	Farmers' Sons.		Farm Workers.		Other Manual Workers.		Artizans.		Other Occupations. Capital.		Other Occupations. No Capital.	
				Total Numbers.	% of Total.	Total Numbers.	% of Total.	Total Numbers.	% of Total.	Total Numbers.	% of Total.	Total Numbers.	% of Total.	Total Numbers.	% of Total.
£30 & under	177	22.95	177=100	72	40.67	71	40.11	20	11.3	12	6.78	2	1.13	—	—
£31—49	144	18.67	144=100	82	57.	33	22.91	15	10.41	5	3.47	5	3.47	4	2.77
£50—99	303	39.29	303=100	231	76.23	47	15.51	14	4.62	5	1.65	2	0.66	4	1.32
£100—149	95	12.32	95=100	82	86.31	9	9.47	—	—	1	1.05	2	2.1	1	1.05
£150 & over	52	6.74	52=100	43	82.69	5	9.61	—	—	1	1.92	2	3.84	1	1.92
Totals	771	100	771=100	510	66.14	165	21.4	49	6.35	24	3.11	13	1.68	10	1.29

SUMMARY TABLE II.

Showing Percentage in each Rent Group of Each Class of Previous Occupation.

Rent Group.	Farmers' Sons.		Farm Workers.		Other Manual Workers.		Artizans.		Other Occupations. Capital.		Other Occupations. No Capital.	
	Total Numbers.	% of Total.	Total Numbers.	% of Total.	Total Numbers.	% of Total.	Total Numbers.	% of Total.	Total Numbers.	% of Total.	Total Numbers.	% of Total.
£30 and under	72	14.12	71	43.03	20	40.8	12	50	2	15.38	—	—
£31—49	82	16.08	33	20.00	15	30.6	5	20.83	5	38.48	4	40.
£50—99	231	45.29	47	28.48	14	28.6	5	20.83	2	15.38	4	40.
£100—149	82	16.08	9	5.45	—	—	1	4.12	2	15.38	1	10.
£150 and over	43	8.43	5	3.04	—	—	1	4.12	2	15.38	1	10.
Totals	510	100.	165	100.	49	100.	24	100.	13	100.	10	100.

The Tables I and II show a complete analysis of the previous occupations of the 771 farmers by rental groups.

The first Table indicates quite clearly that the proportion of "farmers' sons" to the total of each group rises with the size of farm until the last group is reached. But the proportion of those who have been hired farm workers (including some descendants of farmers) falls as the rental value rises. The same is true of other manual workers and artizans. Thus the farmers recruited from manual occupations tend to start at the bottom of the ladder and many of them tend to remain there. Those recruited from "other occupations" tend to miss the bottom rung of the ladder, but not to go in near the top, as 15 of the 23 are found on farms of rental value between £31 and £100.

Occupation of Farmer's Father.

As regards the occupation of the fathers of the present farmers again there is little appreciable difference between the results for the larger and those of the smaller group, although the results do not agree as closely as previously.

Occupations of Fathers of Farmers.

Occupation of Father of Present Farmer.	Larger Group (834 Farmers).		Smaller Group (771 Farmers).	
	Number.	Per cent.	Number.	Per cent.
Farmer ...	624	74.82	592	76.78
Farm Worker ...	90	10.80	82	10.63
Other Manual Worker	62	7.43	45	5.83
Artizan ...	47	5.63	44	5.70
Other Occupations				
Requiring Capital	8	0.96	5	0.64
Not requiring Capital ...	3	0.36	3	0.38
Total ...	834	100.00	771	100.00

With this Table of the results of the analysis of two groups the comparisons end, and analysis is limited to the smaller group only. The following Table shows the occupations of fathers of farmers, classifying the present farmers by rental groups.

The results show that about 75 per cent. of the present class of farmers have descended from farmers, and that 10 per cent. have descended from farm workers. Thus some 85 per cent. of the farming class have a social, though not a physical, inheritance of farming knowledge and experience. They are brought up in a

farming environment and they imbibe farming traditions. The remainder are recruited chiefly from manual working classes, their fathers being chiefly "other manual workers" and "artizans."

TABLE III.

Occupation of Fathers of Present Farmers.

Rental Group.	*Farmer.*		*Farm Worker.*		*Other Manual Worker.*		*Artizan.*		*Other Occupation.* *Capital.*		*Other Occupation.* *Not requiring Capital*		
	No.	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%	
£30 and under	99	55.93	39	22.03	16	9.06	21	11.86	1	.56	1	.56	100
£31—49	107	74.3	14	9.72	11	7.63	10	6.94	1	.69	1	.69	100
£50—99	253	83.49	22	7.26	16	5.31	10	3.3	—	—	2	.66	100
£100—149	87	91.57	5	5.26	1	1.05	2	2.1	—	—	—	—	100
£150 and Over	46	88.46	2	3.84	1	1.92	1	1.92	1	1.92	1	1.92	100
Totals	592		82		45		44		3		5		
% of Totals	76.78		10.63		5.83		5.7		.38		.64		

The predominance of descent from families of farmers is shown in every rental group, but is most marked in the groups of £100 and upwards. This shows the importance of the inheritance of capital for the purpose of starting farms, whether the amount of capital be large or small. The proportions of numbers of fathers who were farm workers, other manual workers, and artizans, decrease as the rental value of farms occupied by sons increases.

But the most interesting result is obtained by comparing the previous occupations of the present farmers with the occupations of their fathers. By this means an indication of the proportion of hired farm workers (in previous occupation) who are actually descended from farmers is obtainable.

Occupation.	Previous Occupation of Present Farmer. Number.	Previous Occupation of Present Farmer. Per cent.	Occupation of Father of Present Farmer. Number.	Occupation of Father of Present Farmer. Per cent.
Farmer's Son or Farmer ...	510	66.14	592	76.78
Farm Worker ...	165	21.4	82	10.63
Other Manual Worker	49	6.35	45	5.83
Artizan ...	24	3.11	44	5.70
Other Occupations				
Requiring Capital	13	1.68	3	.38
Not requiring Capital ...	10	1.29	5	0.64
Total ...	771	100.00	771	100.00

Thus if the two "agricultural" groups are taken together they are almost exactly identical: 675 being found in the first and 674 in the third column. It should be clearly understood that this result is purely accidental and that no reliance can be placed on the expected occurrence of this numerical correspondence. In fact, of 165 "farm workers" by previous occupation, 55 were sons of farmers, 71 were sons of farm workers, and 39 were sons of men in other occupations. No such complete correspondence is found in other occupational groups. Only 24 of the present farmers had been previously occupied as artizans, but 44 were sons of artizans. While the totals in all the other occupational groups in each of the columns will necessarily nearly correspond with each other, there is considerable transposition of occupation from father to son, as shown by differences in numbers between groups. Some of this certainly occurs between the agricultural and the non-agricultural groups.

Occupation of Farmer's Grandfather.

The fluidity of the farming class may best be shown by the fact that of 771 farmers now in control of land only 592 had farmers for fathers and only 522 had grandfathers who were farmers; or that 76 per cent. of the present farmers had farmers for fathers and 67 per cent. had farmers for grandfathers. A further analysis is required to discover how many of the present farmers had both fathers and grandfathers who were farmers. This is not shown in the following Table, for an individual farmer of the present may have descended from a farming grandfather through a father who had another occupation. But the following Table shows the occupation of the grandfathers of present farmers.

TABLE IV.
Occupation of Farmer's Grandfather.

Rental Group.	*Farmer.*		*Farm Worker.*		*Other Manual Worker.*		*Artizan.*		*Other Occupation.* *Capital.*		*Other Occupation.* *Not requiring Capital.*		
	No.	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%	
£30 and under	84	47.45	54	30.5	20	11.3	16	9.06	1	0.56	2	1.13	100
£31—49	85	59.02	31	21.52	16	11.11	12	8.33	—	—	—	—	100
£50—99	229	75.57	27	8.91	25	8.25	16	5.31	4	1.32	2	.66	100
£100—149	81	85.26	10	10.52	2	2.1	2	2.1	—	—	--	—	100
£150 and Over	44	84.61	4	7.65	1	1.92	2	3.84	—	--	1	1.92	100
Totals	523		126		64		48		5		5		771
% of Total	67.83		16.34		8.3		6.22		.64		.64		100

This classification by rental groups shows an increasing proportion of grandfathers who were farmers as the rental value rises, and,

with one deviation, that the proportion of farmers who had grandfathers who were farm workers falls as the rental value rises.

But the most striking fact illustrated by the analysis of the occupations of fathers and grandfathers of the present farmers is that only some 75 or 76 per cent. have descended, even through one generation, from previous farmers. Even allowing for the fact that an increase in the total number of farmers has occurred in the last decade, general fluidity exists. Moreover, there is evidence not only that persons recruited from other occupations "climb the farming ladder," but that farming families descend the farming ladder. Such increases in number of farms as have occurred are mainly in the number of small farms. The process of increasing farms must itself tend to diminish the average size, even to diminish the number of medium sized or large farms, while the total area of farming land is diminishing. And while the number of farms[6] increased between 1911 and 1921 the area of cultivated land (arable and pasture) under all farms decreased by over 6 per cent. While men who had fathers or grandfathers who were farm workers, or "other manual workers," were "climbing the ladder," sons and grandsons of farmers were going out of the industry. Not all of these went out by a descent to manual occupations, for some pass to the trades and professions, mostly to the professions, from the top of the ladder itself. They may of course pass out of the industry at any stage by taking to another occupation in youth without even becoming farmers. But there is indication of a downward drift of farmers in the analysis of quality of farming in relation to family descent.

Quality of Farming.

With regard to the judgments and records of quality of farming in general it must be said that there is some tendency to describe the farming on small farms as poorer than that of the larger farms. Whether this is due to a certain amount of prejudice or is warranted by the facts it would be difficult to say. The comparisons are as follows:—

Rental Groups.	*Per cent. of Total Classified.* Good.	Medium.	Poor.
£30 and under	36.72	44.06	19.2
£31—£49	41.66	44.44	13.88
£50—£99	51.48	36.96	11.22
£100—£149	49.05	43.15	7.36
£150 and over	51.92	34.61	13.46
Average of all groups	46.04	40.59	13.35

[6] That is, the number of farms as business units, taking the increase in number of farmers, as shown by the *Census*, to be an actual increase.

According to judgments the highest quality of farming is found in the group in which rental values range between £100 and £149, for in this group over 92 per cent. is described as medium or good, The quality falls off in the highest group, where only 86 per cent. is described as medium or good. In the lowest group only 80 per cent. is described as of medium or good quality. However, it must be remembered that no classification by area has been made, and that some farms in the lower rental groups will be fairly large as regards area because of poor soil. There is always some tendency to describe farming on poor soil as of poor quality and the instruction to judge the quality of farming by the quantity and quality of crops grown and of stock kept may have increased this tendency. Still, there are no better criteria of the quality of farming, regarded as an art, than the quantity and quality of crops and stock; and the judgments must be accepted. If they are thought to represent some prejudice against the smaller farms they must equally be considered to represent some prejudice against the largest farms. All these judgments are made in respect of farming as an art rather than as a profit-making business. There could be no proper criteria of the latter which could be generally applied; and judging farming as an art is rather more in accord with prevailing general ideas of farmers than judging it as a profit-making business. While all farmers must make profits to continue in business, there are many who would not sacrifice the criteria of the art of farming as a basis of judgment of their success. Not all farmers would sacrifice good farming for a high profit standard, especially when such a standard might be only temporarily maintained.

Relation of Quality to Previous Occupation.

The analysis of the relation of the previous occupation of the present farmers to the quality of farming shows some remarkable results. On the whole, it appears, the highest proportions of good farming are to be found where farmers have had no previous occupation except farming, either as hired workers or as workers or residents on the parental farm. This corresponds with expectations, at least those of farmers. But perhaps few farmers would realise that there is a tendency for farmers' sons who work small farms to show farming of relatively poor quality, but this is shown in this analysis of the judgments recorded. Taking only those farmers who have never had any previous occupation other than that of "farmer's son,"—who in fact have never had any occupation other than farming; the following are the results of rental groups:—

Rental Groups.	*Proportions of Different Qualities of Farming by "Farmers' Sons" (Per cent.).*		
	Good.	Medium.	Poor.
£30 and under ...	38.74	38.74	22.22
£31—£49 ...	41.46	42.68	15.85
£50—£99 ...	51.94	35.06	12.98
£100—£149 ...	48.78	45.12	6.09
£150 and over ...	58.13	32.56	9.30

The best farming here is in the two highest rental groups. And, with the exception of the last group, the tendency for the proportion of poor farming to fall as the rental classification rises is clearly marked. But taking the second and fourth groups in which actual numbers recorded are equal, the proportions of each quality are markedly different. So in spite of the presumption of the possession of some capital with which to start farming it appears that "farmers' sons" on small farms tend to conduct farming of a relatively low quality. One reason for this is that the "farmers' sons" on the small farms include those men of farming origin who are descending the farming ladder. During their own lives, or with the coming generation, they will pass from the farming class. If support of this is needed it can be found in a comparison of the quality of farming by "farmers' sons" and that of men who have been previously hired farm workers. Numbers are nearly even, so comparison is fair.

Quality of Farming.	Rental Groups.			
	£30 and under.		£31—£49.	
	Farmers' Sons.	Hired Farm Workers.	Farmers' Sons.	Hired Farm Workers.
	Per cent.	Per cent.	Per cent.	Per cent.
Good ...	38.74	40.84	41.46	45.45
Medium ...	38.74	42.25	42.68	45.45
Poor ...	22.22	16.90	15.85	9.0

The differences here are fairly clear, and in favour of those farmers who have been previously hired farm workers. On the other hand, those who have been farm workers tend to show farming of poorer quality in the higher rental groups. Numbers here are quite unequal, so perhaps results are not so reliable as in the case above, but the comparison may be given.

Quality of Farming.	Rental Groups.			
	£100—£149.		£150 and over.	
	Farmers' Sons.	Hired Farm Workers.	Farmers' Sons.	Hired Farm Workers.
	Per cent.	Per cent.	Per cent.	Per cent.
Good ...	18.78	33.33	58.13	20.0
Medium ...	45.12	44.44	32.56	40.0
Poor ...	6.09	22.22	9.30	40.0

There is reason to believe that this tendency would be shown, though perhaps not in the same degree, if a larger number of farmers who have been previously engaged as farm workers could be examined. The reasons for it are not obscure. Former farm workers who obtain farms of a rental of £100 and over are apt to be short of capital in the early stages of their careers and often when they reach farms of this size. Moreover, their skill and application in manual work, which serves them well in smaller farms, is not a great element in success on the larger farm. With the larger business they require more of organising capacity and general *managerial* skill. They may attain this by experience on the larger farm, but they frequently do not command it when they extend their acres and their businesses.

With regard to previous occupations of a non-agricultural character, the number of farmers the quality of whose farming is recorded is small. The whole of these occupations are therefore grouped together and the results given for the non-agricultural group.

Quality of Farming of Farmers Previously in Non-Agricultural Occupation.

Rental Groups.	*Per cent.* Good.	Medium.	Poor.
£30 and under ...	23.53	58.82	17.64
£31—£49 ...	37.93	48.27	13.80
£50—£99 ...	40.00	48.00	12.00
£100—£149 ...	100.00	—	—
£150 and over ...	25.00	50.00	25.00
Average all groups ...	35.41	50.00	14.58

The difficulty of dealing with comparisons when numbers are small is illustrated in the fourth group, in which there are only four farmers, all of whose farming is described as of good quality. But if the proportions of the different qualities of farming amongst the

SUMMARY TABLE V.

Relation of Quality of Farming to Previous Occupation of Farmer.

Rental Group.	£30 and Under.				£31—49.				£50—99.				£100—149.				£150 and Over.				All Groups.			
Previous Occupation.	*Tot'l Nos.*	*Good*	*Medium*	*Poor*	*Tot'l Nos.*	*Good*	*Medium*	*Poor*	*Tot'l Nos.*	*Good*	*Medium*	*Poor*	*Tot'l Nos.*	*Good*	*Medium*	*Poor*	*Tot'l Nos.*	*Good*	*Medium*	*Poor*	*Tot'l Nos.*	*Good*	*Medium*	*Poor*
Farmers' Sons	72	28	28	16	82	34	35	13	231	120	81	30	82	20	37	5	43	25	14	4	510	247	195	68
	100	38.74	38.74	22.22	100.	41.46	42.68	15.85	100.	51.94	35.06	12.98	100.	48.78	45.12	6.09	100.	58.13	32.56	9.3	100.	48.43	38.23	13.33
Farm Workers	71	29	30	12	33	15	15	3	47	26	19	2	9	3	4	2	5	1	2	2	165	74	70	21
	100	40.84	42.25	16.9	100.	45.45	45.45	9.	100.	55.32	40.42	4.25	100.	33.33	44.44	22.22	100.	20.	40.	40.	100.	44.84	42.42	12.72
Total Agricultural Group	143	57	58	28	115	49	50	16	278	146	100	32	91	45	41	7	48	26	16	6	675	321	265	89
% of Total	100	39.86	40.56	19.58	100	42.61	43.48	13.04	100	52.52	35.97	11.51	100	47.25	45.04	7.67	100	54.16	33.33	12.5	100	47.55	39.26	13.28
Other Manual Workers	20	2	17	1	15	4	10	1	14	6	7	1	—	—	—	—	—	—	—	—	49	12	34	3
Artizans	12	5	3	4	5	3	2	—	5	1	3	1	1	1	—	—	1	1	—	—	24	11	8	5
Other Occupations ...	2	1	—	1	9	4	2	3	6	3	2	1	3	3	—	—	3	—	2	1	23	11	6	6
Total Non-Agricultural Group	34	8	20	6	29	11	14	4	25	10	12	3	4	4	—	—	4	1	2	1	96	34	48	14
% of Total	100	23.53	58.82	17.64	100	37.93	48.27	13.8	100	40.	48.	12.	100	100.	—	—	100	25.	50.	25.	100	35.41	50.	14.58
Total all Groups.....	177	65	78	34	144	60	64	20	303	156	112	35	95	47	41	.7	52	27	18	7	771	355	313	103
% of Total	100	36.72	44.06	19.2	100	41.66	44.44	13.88	100	51.48	36.96	11.22	100	49.05	43.15	7.36	100	51.92	34.61	13.46	100	46.04	40.59	13.35

whole of the non-agricultural group are compared with those in either or both the agricultural groups some differences are clear.

Quality of Farming (Per cent.).

	Good.	Medium.	Poor.
Agricultural groups ...	47.55 ...	39.25 ...	13.20
Non-agricultural groups ...	35.41 ...	50.00 ...	14.59

The tendency towards farming of medium to poor quality amongst persons who have come to farming from other occupations is thus marked. Although numbers in separate rental classes for the non-agricultural group are small, the total number of the group for which the above comparison is made is 96, and it is unlikely that if a larger number of cases could be examined the results would prove to be radically different. The total numbers in rentals groups according to previous occupations of farmers are shown in Summary Table V, where the whole set of results should be examined.

Relation of Family Descent to Quality of Farming.

For the analysis of the relation of the occupations of fathers and grandfathers of farmers to the quality of farming no division into rental groups has been made, because the general relationship of family descent to quality of farming is best shown in connection with the whole group of farmers. As regards the influence of occupation of fathers it appears, on the whole, that the best farming is done by the men who are sons of farm workers; and that the farming by sons of men who followed non-agricultural occupations tends to be of a relatively poor quality. But in the non-agricultural group, sons of artizans show remarkably good results. The comparison is as follows:—

Influence of Father's Occupation on Quality of Son's Farming.

Occupation of Farmer's Father.	*Proportion of Quality, per cent.* Good.	Medium.	Poor.
Farmer ...	45.77 ...	41.21 ...	13.02
Farm Worker ...	56.09 ...	32.92 ...	10.97
Total Agricultural group ...	47.03 ...	40.20 ...	12.75
Non-Agricultural group ...	39.17 ...	43.3 ...	17.52
All groups ...	46.04 ...	40.59 ...	13.35

It is difficult to assign any adequate reasons for the good results shown by sons of farm workers. But there will not be lacking persons who will account for them by the superior energy and "push" of these farmers. This is an adequate reason in some individual cases, but it is not altogether adequate as a general cause.

And there will not be lacking persons who will explain the poor results attained by the group of non-agricultural descent as being due to a lack of inheritance—social or physical— of farming capacity. Again it may be objected that the reason is not adequate. The better reason is that such men tend to start their farming experience comparatively late in life.

The influence of the grandfather's occupation on the quality of the grandson's farming is not so marked except between the agricultural and non-agricultural groups, for there is no difference between the quality of farming of those who had farm workers and those who had farmers for grandfathers.

Influence of Grandfather's Occupation on Quality of Grandson's Farming.

Occupation of Farmer's Grandfather.	*Proportion of Quality, per cent.*		
	Good.	Medium.	Poor.
Farmer	48.27	38.88	12.83
Farm Worker	48.81	40.94	10.22
Agricultural Group	48.38	39.29	12.32
Non-Agricultural group	33.60	47.54	18.85
Average all groups	46.04	40.59	13.35

Any person who may be inclined to find the reason for the poor results of the non-agricultural group in the preceding analysis in the lack of inheritance of farming capacity may find support in the results shown here. It must be remembered, however, that these two analyses do not necessarily represent the same groups of farmers, or that the farmer who had a farmer for a father necessarily had a farmer for a grandfather. As stated before, the analysis of persons by descent through two generations has not been made. Still, it is a striking phenomenon that the results for the non-agricultural group should again be relatively poor, and that they are very similar to the results shown for sons of men in " other occupations." Again the complete Table is given and should be consulted for the detailed results.

Some further analysis of the records may be pursued, but this will be of a complicated character. The results shown above are the most simple and general that can be obtained from the records.

Conclusion.

Of the results obtained, the most striking perhaps is that of the proof of general fluidity in the farming class. It might have been expected that the class of farmers would show considerable recruitment from the class of farm workers and even from farm workers

SUMMARY TABLE VI.

Relation of Occupation of Farmer's Father and Grandfather to Quality of Present Farming.

Occupation.	Farmer's Father.							Farmer's Grandfather.						
	Good.		*Medium.*		*Poor.*		*Total.*	*Good.*		*Medium.*		*Poor.*		*Total.*
	Numbers.	%	*Numbers.*	%	*Numbers.*	%		*Numbers.*	%	*Numbers.*	%	*Numbers.*	%	
Farmers	271	45.77	244	41.21	77	13.	592	252	48.27	203	38.88	67	12.83	522
Farm Workers.......	46	56.09	27	32.92	9	10.97	82	62	48.81	52	40.94	13	10.23	127
Total Agricultural Group	317	47.03	271	40.20	86	12.75	674	314	48.38	255	39.29	80	12.32	649
Other Manual Workers	11	24.44	27	60.	7	15.55	45	15	23.81	37	58.73	11	17.46	63
Artizans	25	56.81	12	27.27	7	15.91	44	21	42.85	17	34.69	11	22.44	49
Other Occupations ...	2	25.	3	37.5	3	37.5	8	5	50.	4	40.	1	10.	10
Total Non-Agricultural Group	38	39.17	42	43.3	17	17.52	97	41	33.6	58	47.54	23	18.85	122
Total All Groups ..	355	46.04	313	40.59	103	13.35	771	355	46.04	313	40.59	103	13.35	771

who were descended from wage-earning families. But probably few persons would expect to find such considerable proportions of farmers recruited from non-agricultural occupations or descended from non-agricultural families. However, with regard to "other manual workers" and "artizans" in respect of previous occupation, it must be remembered that the last quarter of a century has been a period of depression in many small industries which are carried on in parts of Wales. In certain areas mining or quarrying, especially lead-mining, has been a diminishing industry. In all parts of the country the work of the village artizan has tended to disappear before the supplies of machine-made goods. Consequently, persons in these occupations having a "rural bias" or wishing to remain in the countryside had little opportunity left of satisfying their desires except obtaining access to land.

As regards the agricultural occupations, taking together both farmers and farm workers and the families from which they descended, the modification of the farming class by recruitment from the class of farm workers is also clear and significant. But the effect of this recruitment on the class of farm workers is more obscure. Although some 22 per cent. of the present class of farmers have been hired farm workers, and although some 10 per cent. had farm workers for fathers, the proportion of persons who have descended from families of farm workers who obtain control of land is difficult of ascertainment. The number of hired farm workers has fluctuated much more during the last fifty years than the number of farmers. Moreover, whenever the *Census* enumerates the farm employees it includes a very large proportion of people who are descended from farming families and who will themselves become occupiers of land in future years. During the last quarter of a century the class of farm workers and that of farmers have, on the average, been about equal in numbers, but it does not follow because 10 per cent. of the farmers have been sons of farm workers, that only 10 per cent. of the farm workers by descent became farmers, because of the enumeration of farmers' sons amongst the hired farm workers as stated above. Taking the class of male farm employees as enumerated by the *Census* and excluding those who are actually sons of farmers, it appears that over 11 per cent. have an opportunity of obtaining control of land. If this represents the actual position, the conditions in Wales are very much different from those which are general in England, for there the proportion is much lower.[7] But whatever

[7] See Ashby *Allotments and Small Holdings in Oxfordshire*, pp. 8—9, 88—89, 97—98. But compare Lennard *Ecomonic Notes on Agricultural Wages*, pp. 57—59; and *Wages and Conditions of Employment in Agriculture*, *Cd.* 25 1919, pp. 53, 249, 252, 366.

importance may be attached to figures it cannot be doubted that a large proportion of farmers are recruited from the class of farm workers and that at least an equally large proportion of persons in that class eventually obtain control of land.

While this is true, the reverse side of the picture must not be forgotten. As the total number of farmers has been fairly constant, except during the decade 1911—1921, this recruitment must mean a fairly steady loss of farming personnel, and of capital previously used in farming, to the industry of the Principality. Even during the last decade, when the total number of farmers was increasing, the increase would not be sufficient to account for the recruitment without loss to the industry. In other decades the loss must have been at least equal to the recruitment. Such loss can occur in one or more of several ways: farmers may die without descendants (or without male descendants who establish farming businesses); all the sons of farmers may proceed to other occupations; sons may become farmers by "inheritance" of occupation or actual inheritance of capital or a business and reach financial failure; or farmers may migrate from the Principality. The most important, numerically, are probably the migration of farmers over the English border, and the passing of sons of farmers to other occupations, mainly the professions, when a stage of comparative financial prosperity has been reached. The migratory farmers are not lost to agriculture; and there are certain districts of England in which many representatives of this movement who are good and financially successful farmers can be found. In connection with the loss to the professions it is important that large farms, or farms on which large businesses can be conducted, are rare in the Principality. Consequently when the family has reached a stage of financial prosperity on the comparatively large farm available its members tend to find fresh fields of enterprise. In recent years another step forward has been made by many families through the purchase of farms they occupy, but this cannot continue indefinitely. Nevertheless, a considerable proportion of personnel is lost to the class of farmers by a decline of families down the economic and social scale. Persons who are intimately conversant with farmers and farming in various parts of the Principality will be able to illustrate each of these ways by which loss occurs by recollection of individual cases.

As regards capital, it is also clear that a very large proportion of that used by the present generation of farmers has been saved by them or their fathers. Taking together the farmers who are sons of "farm workers" and of "other manual workers," they represent

over 16 per cent. of the total. This alone does not mean that 16 per cent. of the capital has to be saved, for the greater part of these farmers are occupiers of the smaller farms. Sons of village artizans also frequently have little capital, and when the sons of farm workers, of "other manual workers," and of artizans are taken together they represent 22 per cent. of the total numbers. Even if these 22 per cent. of the farmers occupy the smaller farms, their capital must represent a considerable proportion of the total employed. In addition, many "farmers' sons" who have to take employment as hired farm workers in their youth have to save capital before or after taking farms. But when it is remembered that over 16 per cent. of farmers had farm workers for grandfathers, and 8 per cent. had "other manual workers" for grandfathers, while still another 6 per cent had artizans for grandfathers—over 30 per cent. of farmers derived from these origins—it is evident that the capital saved by each generation of farmers is not negligible in quantity. Probably some 20 to 25 per cent. of the capital now used has been saved by the present farmers and their fathers.

It is possible for some farm workers or other persons of similar class to "marry money," by marrying into farming families, but the greater part of the capital they use is saved. The saving process is partly mechanical and not necessarily accompanied by feeling of self-denial, except possibly in the early stages when wages are saved. When once land is obtained the "saving" is rather by increasing livestock by turning to breeding purposes instead of immediate realisation, or by the purchase of equipment required, than by saving of cash which is in hand. Farm workers or other persons of similar class tend to maintain their consuming habits when they become occupiers of land. New standards of living do not appear until a new generation begins to grow up. Some families even suffer in their consumption when they pass from the class of farm worker to that of self-supporting cultivator. This may not be general, but it appears probable that a supply of productive credit might make the process of passing from one class to the other, and of "climbing the ladder," an easier and more satisfactory one.

Similarly, more use of facilities for education or advice might make the results of this process rather more satisfactory to the nation at large than they appear to be. Although the farmers recruited from the class of farm workers show good results in quality of farming on the smaller farms, they appear to show poor results when they reach the larger farms. But in the case of farmers recruited from non-agricultural occupations or non-agricultural families there is a marked tendency to farming of medium to poor

quality. Such persons, recruited mostly from a rural environment, have frequently a general acquaintanceship with the practice of the arts of farming, sufficient to enable them to live by it, and some have gained enough knowledge to enable them to make progress in the business, but apparently their personal equipment is not such as enables them to make as good use of land as their neighbours who have had a more intimate acquaintance with the industry.

The most important conclusion that may be drawn from the study is not shown directly by the numerical results. The farming class is a fluid one, and men of varied previous occupations and of various social origins make a success of the art and business of farming. If the total number of farmers is to be increased, and recruiting from varied sources to be continued, not only will increased provision for or use of educational facilities and increased supply of capital or credit be necessary, but changes in farming methods and practices must follow if the results are to be satisfactory. There is now a desire for the farming ladder, but as farms increase in number they must also become smaller and the ladder must become shorter and narrower at the top. Consequently procedure from one economic stage to another must be by intensification of use of land rather than by " laying field to field " as is now the case. The desire is now for the medium or the larger sized farm, and the methods practised on the small farms are apt to be copies of the methods more suitable to those of larger area. But as the avenues to the larger holdings become more constricted the occupiers of the small farms must adopt methods specially suitable to the size of their holdings if they are to attain real success or gain continued satisfaction in the industry.

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THE PLACE OF CEREAL GROWING IN WELSH AGRICULTURE.

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In considering the place of cereal growing in British agriculture we may take into account many groups of facts. We may consider the national requirements of cereal growing as a measure of defence, or the national need of producing more cereals to reduce the amount of imports which have to be paid for at a time in which export trade meets many difficulties. Or we may consider the relation of cereal production to general farm economy and particularly in relation to the possible alternative uses of land and the relative amount of agricultural income or farming profit which may be obtainable by producing cereals or by producing other things. If we think of all or of any of these considerations, we shall make some sort of a survey of the conditions of the trade in imported cereals, especially of supplies and prices. But when we have made a survey of the trade in imported cereals, and arrived at conclusions as to imported supplies and their prices, these conclusions will not immediately apply to all types of British agriculture. So we shall then have to take the considerations of national needs, conclusions as to the imported trade, and apply these to local systems of British farming according to the conditions which locally prevail.

This paper is not an attempt to deal in general with the place of cereals in British agriculture,[1] for that would be an impossible task in the space available. Every district, with its physical characteristics and the characteristics of its farming, needs separate consideration. This paper is consequently an attempt to deal only with the characteristics of Wales, and with its system of farming, in relation to the production of cereals. But in any general study of the place of cereal growing in British farming, the place of cereal growing in Welsh farming is an important item. Wales and Monmouth occupy nearly one-tenth of the total land surface of Great Britain and of the total cultivated area they supply nearly one-tenth, but of the total arable land they supply less than one-twentieth. Consequently any scheme for increasing production of cereals must take into

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[1] This paper was read at the Southampton meeting of the British Association, 1925, in the discussion, "The place of cereal growing in British agriculture."

account conditions in Wales, and any proposals for extending the cereal area which would entail equal contributions from all areas would affect the Welsh farmers very directly.

Wales, unlike England, and even unlike Scotland, has no predominantly arable or corn growing areas. Although it is not equally pastoral in all areas it is predominantly pastoral in every district. In the counties of Anglesey, Denbigh and Cardigan, which show the highest proportions of arable land, only 33, 35 and 37 per cent. is shown as against 75 per cent. for an English county like Norfolk. There may be a few Welsh farms which have an area of plough land greater than that of grass, but there is no district known to me in which the proportion of arable generally exceeds that of pasture land. Thus there is no predominantly arable farming, depending mainly for its profits on cereal production and prices. In England about 21 acres out of every hundred acres of cultivated land are devoted to cereals, in Wales only a little over eleven acres are so used. There are also marked difference in the variety of cereals grown. For the total cereal acreage the following are recent figures (in percentages):—

Proportion of cereal area (per cent.).

	England.	*Wales and Monmouth.*
Wheat ...	34	12
Barley ...	25	20
Oats ...	37	62
Mixed Corn ...	2	6
Rye ...	2	1
	100	100

Thus over two-thirds of the cereal acreage of Wales is devoted either to the pure oat crop, or to mixed corn in which oats are an important item. Wheat, the chief bread corn, occupies quite a subordinate place in the cropping system of the Principality.

The reasons for this are doubtless partly historical and partly geographical and agricultural. Although wheaten bread became the staple cereal food of the English rural population, except in some districts in the Northern counties, in the eighteenth century, it was not so adopted in parts of Wales until about a century later. Up till 1870 barley and oats supplied a large part of the farinaceous food of the farming population in many parts of Wales.[2] In the greater part of the four most northerly counties, wheaten bread was commonly consumed. But in Merioneth bread was commonly made

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2 See: Sixth Report by Medical Officer of Health to Privy Council, 1864; and Third Report on Employment of Women in Agriculture, C. 70, 1870.

partly of barley and in Cardigan it was made of mixtures of barley or rye with wheat. In Montgomery, it was said, barley and oatmeal bread were common up to 1850, and even about 1870 bread consisting of two parts of barley to one of wheat was found in some districts. In parts of Pembrokeshire barley bread, or a mixture of barley and wheat was common. In Carmarthenshire also barley was a common ingredient of bread up to 1860, and in some parts to a much later date. "Flummery" made of oatmeal everywhere supplied a not unimportant part of the dietary of the farm population. On the south-eastern side of the Principality wheaten bread was more common. But it is clear that barley and oats formed an important part of the dietary of the farm population during the period in which the modern types of farming were being determined. In some districts in fact, barley and oats continued as ingredients of bread up to about 1890, while oats continued to be eaten in different forms a little later. And when the farm population began to confine its consumption to wheaten bread its needs were supplied chiefly by flour from imported wheat.

Another very important reason for this situation is that of altitude of land, since very little wheat can be grown above 600 feet, whereas the oat crop can be, and is grown up to a height of a 1,000 feet or more above sea level. Taking Wales as a whole, however, wheat is not grown because it does not fit in with the agricultural economy. On most of the areas where a low altitude affords conditions favourable to wheat growing, the cultivated area is monopolised by temporary and permanent grass. In a pastoral system, oats as a complementary crop is more suitable than wheat. As food for livestock, oats and barley are more widely utilised than wheat, and this partly explains why in a pastoral system, the aim of which is raising livestock and livestock produce, wheat is grown only on a small scale. Wheat may be successfully used for some feeding purposes, but it is not commonly so used.

In discussing the distribution of crops over different areas, geological and geographical features must be mentioned. As regards geological features, however, it is difficult to trace any direct influences, except in a few small cases, between formations and cropping, or at least only in so far as certain geological formations coincide with high altitudes.

As is to be expected, the distribution of rainfall is largely governed by the contours of the country, and those areas where rainfall is heaviest generally occur at high altitudes. Consequently, it is the consideration of altitude with its influence on rainfall which

will be the greatest determinant of crop distribution. That does not mean to say that the density of cropping will be in inverse ratio to altitude, but it does imply that in many cases altitude will determine whether a crop is grown at all or more widely grown.

In 1923 there were only 36,500 acres of wheat in the Principality. Very little wheat is grown above a level of 600 feet and this explains why (with the exception of the Dovey Valley) a broad strip of Wales stretching from Snowdon to North Glamorgan grows no wheat. Still some wheat is grown in Radnor and Brecon although, with the exception of the Wye, Usk and Swansea Valleys, practically the whole area of both counties is above the level of 600 feet. An occasional crop of spring wheat may be seen at altitudes of 900 feet or more, but such crops are sufficiently uncommon to be remarkable. On the other hand wheat is very thinly distributed in some of the low lying counties. There is hardly any grown in Anglesey or the Lleyn Peninsula; and, in 1923, Pembrokeshire only grew a thousand acres. In fact, eight counties, including Anglesey, Carnarvon, Merioneth, Brecon. Radnor, Pembroke. Carmarthen and Glamorgan contained in 1923 only just over a third of the total wheat acreage of the Principality. Some reservations with regard to density of distribution must be made for parts of Glamorgan and Carmarthen. Along the Glamorgan coast, especially the hinterland of Barry and westwards from that point, wheat is extensively grown. The same might be said of the area in Carmarthen immediately on the lower right bank of the river Tywi. It is also true that, while over the greater part of Glamorgan the area devoted to wheat is very little, the crop is distributed fairly evenly over the whole of the county of Carmarthen. The position of wheat in the agricultural economy of this county can be viewed from the right perspective when it is realised that less than one per cent. of the total cultivated area was devoted to wheat growing in 1923.

The bulk of the wheat acreage of Wales is distributed in different proportions between the remaining counties, Denbigh, Flint, Montgomery, Cardigan and Monmouth. Of the areas in this group Monmouth, the Severn Valley and eastern parts of Montgomery, east Flint, and the Vale of Clwyd show the most marked concentration of wheat growing. In 1923, Montgomery was the county with the biggest wheat acreage, but even there only 3 per cent. of the total cultivaed area was under wheat. Other areas in which concentration is more or less marked are west and south Cardigan, the lower Conway Valley, and the Flintshire coast. Briefly put, the meagreness of the wheat area in Wales can be

explained by the fact that there are large areas physically incapable of growing wheat for sale under the market conditions which have existed for the last half-century and the equally important fact that wheat growing is not well adapted to complement the main system of farming.

Barley plays a much more important part than wheat in the crop system of Wales since 65,314 acres were grown in 1923. The distribution of this crop follows on lines similar to that of wheat in so far as altitude is concerned. But otherwise there are important differences in its distribution. There are grounds on which to argue that barley competes with wheat for land. It is significant that in 1923 in some of those counties where wheat was the more extensively grown, the barley acreage was less than the wheat. This is particularly the case in Montgomeryshire and Monmouth, and in the latter the barley acreage was less than half the area under wheat. The same position existed in 1924. In all Wales except these two counties and Flintshire the barley acreage was greater than that of wheat. The degree of difference varies from the case of Glamorgan, where just a little more barley than wheat was grown, to the extreme case of Carnarvon, where in 1923, 4,136 acres were grown compared with 162 acres of wheat. Equally notable is the case of Pembroke, where the area under barley was 13 times as great as that under wheat. Barley growing is most concentrated in the Clwyd Valley, the Lleyn Peninsula. the lower Severn Valley of Montgomery, the coast of Cardiganshire, and especially the lower Teifi Valley, the greater part of Pembroke and the Gower Peninsula.

Oats is by far the most important cereal crop in Wales, as almost 195,000 acres were grown in 1923. This was about 61 per cent. of the total area under cereal crops. In England, on the other hand, only 36 per cent. of the cereal area was sown to oats.

For every 100 acres of cultivated land there were 7.7 acres of oats in England and almost 7 acres in Wales. For the preponderance of oats in the Welsh farming system there are two great reasons. Firstly, the geographic features of the country do not affect oat-growing to the extent that they militate against the growth of other cereal crops. For oat-growing, the climate of Wales is comparatively suitable, and since oats is a hardy crop, it can be grown with success up to the level of a thousand feet. There are a few areas in Wales where oats is not grown. These are Snowdonia, the Merioneth Hills (especially the Cader Idris Range, and the Berwyns), the Plynlymon Range, and the Brecknock Beacons, where areas under this crop are small if they exist at all. But the attempts

to grow oats in some of the mountainous districts show the courage and determination of the Welsh farmer. The second factor determining the extent of oat-growing is that in the stock raising system of Wales, a cereal crop such as oats is absolutely essential. The correlation between the distribution of oats and of cattle is close and significant. As food for horses, oats is essential, and it is an equally important item in the diet of cattle as they are raised on Welsh farms. The areas in which oat-growing is most concentrated are Anglesey, where in 1923, about 93 per cent. of the cereal and 12 per cent. of the cultivated area was under the crop, the Conway Valley, South Cardiganshire, North-east and West Pembrokeshire. A good deal is grown in the Lleyn Peninsula, East Denbigh and Flint, the Severn, Wye, Upper Usk and Teifi Valleys, the greater part of Cardiganshire and Radnor. Some of the counties where the proportion of the oat acreage to the total cultivated area is lowest are Merioneth, Carmarthen, Glamorgan and Monmouth. The contours of the county and the predominance of sheep as the chief item of livestock is largely accountable for this in the case of Merioneth. The distribution of cattle in Glamorgan and Monmouth are well below the average, and in the case of the latter county, wheat is an important arable crop. As regards Carmarthen, the fertility of its soil renders it suitable for summer grazing, and it must be remembered that the proportion of its permanent pasture to the total cultivated area is the highest in Wales. Almost 60 per cent. of the total land surface of the county and 83 per cent. of the cultivated area is under permanent pasture. The fact that in 1923, about 5,500 acres of mixed corn was grown is also an important factor in reducing the area under oats in Carmarthen. But taking Wales as a whole, oats are by far the commonest and most important arable crop.

There are some outstanding differences between the average yield of the oat crop in various counties. The average yield in Wales for the period 1913—22 was 11½ cwt. to the acre, compared with 13½ cwt. for England. The highest yields per acre occur in Anglesey, with 14.7 cwt. and Pembroke with just over 14 cwt. Merioneth, Flint, Glamorgan and Monmouth have yields above 12 cwt. Of the counties where the yield is below the average are Radnor with 8.1, Brecon with 8.7 and Montgomery with 8.9 cwt. These lower figures coincide with the smaller areas devoted to the crop.

In considering the three main arable crops, 93 per cent. of the total cereal area has been reviewed, so that little need be said about

mixed corn and pulse. Mixed corn is not extensively grown, and of some 18,500 acres devoted to this crop in 1923, the counties of Carmarthen, Pembroke, Cardigan, Montgomery and Denbigh contained about 80 per cent. of the total.

Considering the Principality as a whole, very small quantities of cereals are grown, and of these only the minor portion is grown for sale. Of the wheat crop, which is very small. probably not more than 25 to 30 per cent. of the produce is sold off the farms. In the case of barley, some 33 to 40 per cent. appears to be sold off the farms on which it is grown, but a good deal goes back to other farms in the vicinity. Very little Welsh barley is now used for malting purposes, though a good deal was so used a few years ago in several localities. There are a number of factories in different parts of Wales using locally grown oats for production of oatmeal for human use, and some farmers still get a part of their oats dressed for home consumption. But the proportion of this crop now used for human consumption is small. Probably only 10 to 15 per cent. of the oats grown—by far the most important cereal crop—are sold off the farms on which they are grown. Some of those sold return to farms again.

While during the last fifty or seventy years the population of the Welsh farms have developed the habit of generally eating the wheaten bread of commerce, the livestock of the farm have consumed more and more of the cereal products of the land. Indeed the most striking fact about crop production in Wales is that the farm population with its present production and consumption could supply only a very small part of its bread requirements. And over Welsh farming as a whole far more concentrated food is consumed by Welsh stock than is produced in the arable fields.

The present place of cereal growing in Welsh agriculture is that of an adjunct to live stock production, and so far as it is possible to read the economic signs that is the place it will continue to occupy. It is, in fact, sometimes suggested that the Welsh farmer has begun to consider his cereal crops from the point of view of obtaining the greatest and most convenient supplies of fodder for live stock. He has undoubtedly done this to some extent in the predominant place which he has given to the oats, but it is further suggested that in the oat crop he has been trying to find a variety which will give the greatest weight of straw and corn, with a straw which makes good fodder. If his efforts have been so directed, they have not tended to produce greater weights of straw, for it appears that there is a general decline in the yield of straw in recent years.

Yields of Straw.

	Wheat.	Barley.	Oats.
		Cwt. per acre.	
1905—1914	24.0	18.8	21.7
1915—1924	22.2	16.5	18.8

There cannot be any doubt, however, that the Welsh farmer's interest lies in getting the greatest feeding value from the whole crop, rather than from the grain alone, especially in the case of oats. A great part of this crop over the Principality is chaffed and fed to stock without threshing. In some districts practically the whole crop is fed in this way; and this appears to be the most economical way of dealing with it, especially as regards labour.

In the case of barley, also, the crop is mainly an adjunct to live stock production; and a feeding rather than a malting type is required. In some districts the present area of barley might be superseded by oats were it not for the fact that this crop can be sown later in the spring, and many farmers think that it makes a better cover for the seeds of clover and rotation grasses. This is doubtful, for in some parts of the Principality oats are the chief, almost the sole "nurse" crop. More barley might possibly be used for pig-feeding, but for general purposes the Welsh farmer prefers the oat crop because of the greater utility of the straw.

The possibilities of the expansion of wheat production are very small under present circumstances, and even during the War period the expansion of the acreage of other cereals was much more marked than that of wheat. The restriction of wheat cultivation, apart from the need of food for livestock, seems to be largely connected with the difficulty of autumn cultivation and planting in many parts of the Principality. The harvest is often late, and the land is wet before opportunity occurs for its cultivation. Moreover, heavy winter rainfall in some districts would destroy the seedlings, also heavy grazing of winter crops occurs in some districts, and this further restricts the acreage and yield. The chief possibility of increasing the wheat acreage of Wales is dependent upon the development of good varieties of Spring wheat fitted for the local conditions. There is a possibility of using more wheat for poultry food with an increase in poultry stock, and perhaps of using more wheat for pigs if methods of feeding it were better known. But suitable Spring wheats are required before a greater acreage will be sown.

The differences between cereal growing in England and in Wales are not limited to the difference in the proportion of the cultivated land which is devoted to the production of corn. There are differences in yield, in quality and price; also in recent years

differences in purposes of production. As regards yields the differences, which are to the disadvantage of Wales, are easily summarised.

Crop Yield per acre.

Average 1913—1922.

		England.		*Wales.*
Wheat	...	17.2 cwt.	...	15.1 cwt.
Barley	...	14.8 cwt.	...	13.6 cwt.
Oats	...	13.5 cwt.	...	11.5 cwt.

Thus there is difference of 2 cwt. per acre in the cases of oats and of wheat and of 1 cwt. in the case of barley.

As regards quality of grain it is difficult to indicate more than general differences, for no special studies have been made. But in the case of oats, some varieties commonly grown produce a small grain; and in the case of barley there is little now produced that is of malting quality and practically none now used for that purpose. These differences, though general, are shown in prices. for those for Welsh grain are generally lower than English: the average differences over a long period being about as follows:—

Wheat	...	1/6 per quarter.
Barley	...	9d. per quarter.
Oats	...	3/2 per quarter.

Only a very little importance can be attached to the difference in the price of wheat for very little is sold in Wales and a disproportionate part of that appearing in the markets is for seed purposes. But in the case of oats the difference in general selling quality is quite clear. The difference in the prices of oats of the two countries is quite consistent; and that in the prices of wheat is fairly consistent, although occasionally the price of Welsh is higher than that of English. But a change seems to be occurring in regard to barley prices. Between 1904 and 1913 prices of Welsh barley tended to be a little higher than those recorded for England and Wales combined: and this tendency has also been shown since 1914. As a lot of Welsh barley does not find its way into the general cereal-market, prices are more subject to the influences of demand on Welsh farms —for feeding purposes—than to general influences. On the whole, it appears that Welsh cereals fetch lower prices than the English produce, partly because of lower selling qualities, but also partly because of the smaller quantities marketed and difficulties of transport.

Taking into account the differences in yield and in prices, it is very evident that the Welsh farmer is not in as good a position as the English farmer to produce cereals for sale, even on the land which

he now devotes to their production. There are no differences in costs of production which would tend to counteract these differences in yields and prices. Indeed, in production for sale there are certain costs, such as those of threshing and haulage to market, which would tend to be higher in Wales than in England.

The future of cereal production in Wales is therefore chiefly bound up with the production of food for livestock. With the system of alternating husbandry which prevails over large parts of the Principality, the Welsh farmer can extend his arable acreage almost at will, but he has to be convinced that the results will pay for the costs. While in some parts of the country the farmers must continue to plough their pastures in rotation in order to maintain a good turf, it does not follow that they will continue to grow cereals on the scale of the past. The rape pastures which are now extending in some districts may take the place of one of the cereal crops in the rotation as a " cover " for the seeds of clovers and grasses. And if the cereal acreage is to be increased it can only be by providing the farmers with varieties of crops that give better results for their main purposes —the feeding of livestock.

The farmers of Wales are changing the nature of their livestock products and improving their qualities. The store cattle are sold at a younger age and in better condition than formerly. The old wethers amongst the sheep flocks are giving way to lambs, either fat or in a good store condition. In this process of improving livestock, the arable land has its own part to play. But its future contribution is as likely to be in the form of green crops for direct feeding to stock as in the greater production of cereal crops. Efforts are being made by the Welsh Plant Breeding Station to supply varieties of cereals specially suited to Welsh conditions and the purposes of Welsh farmers, and these will assist in the maintenance of the area of cereals. But even these cereals will be more for the production of livestock than for direct human consumption.

Notes.

Average Prices of Cereals in Wales and England.

	England and Wales. s. d.	*Wales only.* s. d.	*Difference.* + or — s. d.
Oats.			
1867—1920	23 3	20 2	— 3 1
1904—1913	18 5	16 6	— 1 11
1914—1920	41 10	39 10	— 2 0
Barley.			
1867—1920	33 5½	32 8½	— 0 9
1904—1913	25 8	26 4	+ 0 8
1914—1920	58 1	58 6	+ 0 5
Wheat.			
1867—1920	41 1	39 7	— 1 6
1904—1913	31 6	31 0	— 0 6
1914—1920	64 0	62 8	— 1 4

Yields of Cereals in Wales (excluding Monmouth).

Bushels per acre.

	Wheat.	*Barley.*	*Oats.*
1885—89	22.73	27.27	31.64
1890—94	23.95	28.78	33.51
1895—99	24.35	29.41	32.88
1900—04	25.68	31.04	33.42
1905—09	27.59	31.22	35.76
1910—14	27.54	30.90	34.76
1915—19	28.12	30.08	35.46
1919—24	27.12	26.99	29.64

CAPITAL AND EQUIPMENT ON SOME WELSH FARMS.

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Amongst the many broad contrasts which can be drawn between modern and medieval agriculture is the greater importance of capital in the present day organisation of production. Even in the last fifty years, to take an example, the revolution wrought by the substitution of manual labour by capital equipment in the form of implements and machinery for the accomplishment of farm work is patent to all familiar with the countryside. Again, between agriculture and the other industries of to-day, one of the chief contrasts turns on the subject of capital—the sources from which it is derived, the regularity of its use, the amount which is amalgamated for use in one enterprise, the rapidity of its turnover, and the rate of interest earned.

Moreover, agricultural capital does not submit to those rigid divisions into which economists have classified industrial capital. The main distinctions drawn are those between *sunk, fixed, circulating* and *floating capital.* It is true that some of the farmer's capital falls naturally into each of these groups. Permanent improvements, such as drainage works and buildings, fall naturally into the class of "sunk" capital. Implements and machinery fall naturally into the classification of "fixed" capital, since they can be used many times in productive work without being worn out. Such feeding stuffs and fertilisers as are held in stock, since they can only be used once, can be designated as circulating capital,

whereas cash in hand or at a bank and credit is definitely floating capital. But a moment's reflection will show that many important items of farm capital do not fall into such exclusive classifications. The capital invested in livestock can be taken as an example. From the standpoint of the work which they perform, horses can be regarded as fixed capital; but in so far as they are bred for sale, are circulating capital. The same difficulty presents itself when considering cattle and sheep. Apart from production for direct sale by the farmer, these animals are kept for breeding, milk producing in the case of cattle and wool in the case of sheep. In the case of a calf born, it may pass from the farm within a few weeks as veal, in a year or two as a store, or in less than three years as beef; or it may stay on the farm ten years before being sold, meanwhile producing milk and calves. Or in the case of a lamb, it may pass off within six months in fat or store condition, or stay on the farm for reproduction for six years. Grain is another case in point, since it can be fed to stock or sown instead of being sold immediately. It is evident then that agricultural capital, comprising as it does dead-stock, such as fixtures, implements, machinery and tools, consumable produce and manures, "tenant right" and livestock, does not admit of rigid classification on the orthodox lines. Again between industrial and farming capital there is an important difference relative to depreciation. In the factory, a certain proportion of the value of equipment is written off each year to cover wear and tear and depreciation. The deadstock of the farm is subject to similar depreciation, but the livestock capital of the farmer on the other hand may replace itself from year to year and in some stages of farm development the livestock may prove to be appreciating rather than depreciating in real value.

There seems to be, however, a natural and useful classification of farming capital between that which is directly productive and that which is indirectly productive. Clearly live and dead stock capital contribute to production in different ways. The major part of livestock is directly productive irrespective of the particular use to which it may be put. Normally for food, shelter and attendance given to animals, there is a direct return in some form or other of food for human consumption. In the case of the farmer who breeds store stock for sale, his return—apart from manure—will be concentrated in the sale price, and not distributed over a period as in the case of the dairy farmer. But whether the animals are kept for what they produce on the farm or for the return when leaving the farm, they are directly productive.

There is a very real sense in which this cannot be said of implements and machinery and such equipment can be justly described as indirectly productive. Such equipment, not being bought with a view to sale at a later date, is invested in to enable farm operations to be performed. The return on the investment is determined by the price or value received for the product of the work done. It may be received through direct sale of crops or through sale of animals fed on crops. The economy of such equipment can be measured by the amount of work which is derived from it, and its interest earning capacity assessed on this basis. In the following discussion of inventories made in 1920 and the Spring of 1921 on Welsh farms, some measure of the economy of capital equipment on different farms will be possible.

The twenty-one farms are situated in North and South Wales, and are generally fairly representative of Welsh farming since the system adopted was mixed stock raising. These farms are divided into size groups of 1—100 acres, 100—200 acres, and over 200 acres. There are some differences between groups and individual farms which claim attention.

TABLE I.

Division of Acreage on Twenty-one Welsh Farms.

	All Groups.	Group 1. 1—100 acres.	Group 2. 101—200 acres.	Group 3. Over 200 acres.
Number of Farms ...	21	5	11	5
Total Acreage ..	3,045 acres.	328 acres.	1,505 acres.	1,212 acres.
Enclosed Pasture ...	1,896 acres.	254 acres.	972 acres.	670 acres.
Arable Land ...	675 acres.	74 acres.	282 acres.	319 acres.
Total Cultivated Area	2,571 acres.	328 acres.	1,254 acres.	989 acres.
Rough Grazings ...	474 acres.	—	251 acres.	223 acres.
Percentage Arable to Total Cultivated Area	26.23 %	22.5 %	22.47 %	32.25 %
Percentage Arable to Total Area ...	22.16 %	22.5 %	18.7 %	26.3 %
Average size of Farms	145 acres.	65.6 acres.	136.8 acres.	242.4 acres.

The average size of the farms in each group is perhaps best shown in this way:—

	All Groups	Group 1. 1—100 acres.	Group 2. 101—200 acres.	Group 3. Over 200 acres.
	Acres.	Acres.	Acres.	Acres.
Arable ...	32.1	14.8	25.6	63.8
Pasture ...	90.3	50.8	88.4	134.0
Rough grazings ...	22.6	—	22.8	44.6
Total ...	145.0	65.6	136.8	242.4

In Group 1 there were no rough grazings attached to any of the farms, and although the proportion of the arable area to the total cultivated is below the average, the proportion of arable to the total area is a little above the average for the three Groups. One farm is definitely of a pastoral character, since only 15 % of the total area is arable land, and in 1920 only 5.75 acres of cereal and green crops were grown. One feature of the stocking of the farms in this Group is the comparative absence of sheep, there being only 134 sheep on all five farms.

The farms in Group 2 are more varied in system and the pastoral character is seen from the fact that only 18.7 % of the total area is classified as arable land. About 17 % of the land of these eleven farms is rough grazings, and some of the farms are sheep farms. On one farm of 124 acres there were only two acres of arable; and in two other farms the proportion of arable land to the total area is 9 % and 12 %. On the other hand, the arable area on one farm is 35 % of the total, whereas on several it is between 25 % and 30 %. It is clear that this Group contains farms of varying systems, and this will be reflected in the analysis of capital.

Of the farms in Group 3, one is a sheep farm of 224 acres, only four of which are arable land. Two of the remaining farms are much above the average for Wales in respect of proportion of arable to total area, since over 36 % of the land is under the plough; and on the two remaining farms the arable land is 25 % and 28 % of the total area. Pigs form an important item of livestock in this Group.

All the inventories for these farms, except one made in October, 1920, were made in the Spring months of 1921. It will be remembered that the prices of agricultural products and requisites were very much higher then than at present. But since the measure of capital must be made in terms of money, these inventories taken at approximately the same time can be taken as an index of the types of capital equipment on these farms, and consequently of its productivity. It is unfortunate that capital held in cash or bank balances is not included in any of the inventories, and a valuation of produce and tenant right in so few that it has been omitted from the analysis. But the chief item missing is that of tenant right, for there was little unconsumed produce on the farms.[1]

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[1] The particulars of valuation for nine farms included both "Produce" and "Tenant Right," and on these nine farms these two items make an addition of 23 per cent. to the total for the classes of capital shown in the Table.

Taking all Groups together, it is seen that livestock is by far the most important class of the capital herein recorded, and that cattle is the predominant item in the class. Probably sheep would claim more than 10 % of the capital if the whole of Wales was considered, and poultry is perhaps under the average, since these two classes of livestock are not kept on several of the farms. An attempt to classify the " dead stock " has been made. It is not possible to make a rigid classification of implements and vehicles according to specific use, for some have many uses. For instance, the mower may be and on small farms is frequently used for harvesting corn, but the cultivating implements are used almost solely on arable land, while vehicles are in general use for all purposes. It is, however, possible to distinguish specific use in the case of dairy utensils, and of equipment used for sheep. In the classification of equipment the " horse equipment " includes harness and gear in use for the general horse-work of the farms. " Food preparing machinery " includes stationary power, whether engine or water-wheel, chaff-cutters, pulpers, crushers, etc. " Sheep equipment " consists of troughs, wire netting, or other fencing used specially for sheep, with shearing and dipping requirements. " Haulage " consists of all the wheeled vehicles on the farms. " General " equipment consists of small tools, sacks, sheets, etc., but mainly of small tools. In the " field equipment," the " harvesting " implements include mowers, sometimes with reaper attachments, self-binders, pole and rotary elevators, etc., used for either or both hay and corn harvests. The " cultivating " equipment is mainly used for the arable land, though some, like chain-harrows and rollers, may be used on pastures and meadows. Fixtures in the form of buildings erected by the tenant claim but a small proportion of the capital.

On examining each acreage grouping separately, the first fact that emerges is that only about 60 % of the capital in Group 1 is invested in livestock, compared with 74 % for Group 2 and over 75 % for Group 3. In other words the smaller farms stand in clear contrast to the larger in the relatively small proportion of capital invested in directly productive form. In the three items of horses, cattle, and especially sheep, Group 1 is below the average. It seems that the proportion falling to horses in Group 2 is rather high, but it must be stated that on the eleven farms in Group 2 there was only one tractor, there being one tractor on the smaller farms and three in the group of farms over 200 acres. On individual farms, according to system, there is a wider divergence than is shown in the acreage grouping comparisons. Of the capital analysed, only 45 % was invested in

TABLE II.

Summary of Live and Dead Stock Equipment on 21 Farms (excluding Produce and Tenant Right).

	Total Value, All Groups. £ s. d.	*All Groups % of Total.*	*Group 1.* £ s. d.	*% of Total.*	*Group 2.* £ s. d.	*% of Total.*	*Group 3.* £ s. d.	*% of Total.*
LIVESTOCK.—Horses	5,875 5 0	13.96	686 10 0	10.21	2,990 15 0	16.97	2,198 0 0	12.37
Cattle	17,879 10 0	42.47	2,666 0 0	39.67	7,664 10 0	43.57	7,549 0 0	42.5
Sheep	4,365 18 0	10.37	423 15 0	6.32	1,786 18 0	10.14	2,155 5 0	12.13
Pigs	1,918 18 0	4.55	145 10 0	2.16	379 0 0	2.1	1,394 8 0	7.85
Poultry	316 0 0	.75	59 0 6	.87	167 14 0	.95	89 5 6	.52
Total Live Stock	30,355 11 0	72.1	3,980 15 6	59.25	12,988 17 0	73.73	13,385 18 6	75.35
DEAD STOCK EQUIPMENT.—1. Dairy	547 2 2	1.29	151 17 6	2.25	253 8 0	1.43	141 16 8	.79
2. Horse	1,026 18 1	2.44	217 15 0	3.24	355 18 7	2.01	453 4 0	2.55
3. Food Preparing	2,203 16 4	5.23	578 10 3	8.62	1,011 16 1	5.74	613 10 0	3.45
4. Sheep	119 9 5	.28	19 1 0	.28	39 8 4	.22	61 0 1	.34
5. Haulage	2,044 2 0	4.85	548 16 8	8.16	789 1 8	4.49	706 3 8	3.97
6. General	725 4 10	1.72	96 3 10	1.43	235 3 8	1.33	393 17 4	2.21
Total Dead Stock Equipment	6,666 12 10	15.83	1,612 4 3	23.98	2,684 16 4	15.22	2,369 12 3	13.34
FIELD EQUIPMENT.— 7. A. Harvest	1,583 17 5	3.76	382 12 0	5.69	626 10 9	3.55	574 14 8	3.23
B. Cultivation	2,093 15 6	4.97	475 11 0	7.07	539 17 8	3.06	1,078 6 10	6.07
Total	3,677 12 11	8.73	858 3 0	12.76	1,166 8 5	6.61	1,653 1 6	9.3
Total Value	40,699 16 9	96.66	6,451 2 9	95.99	16,840 1 9	95.56	17,408 12 3	97.99
Fixtures	1,397 11 10	3.32	269 6 8	4.	776 14 6	4.41	351 10 8	1.98
GRAND TOTAL	£42,097 8 7	100.00	£6,720 9 5	100.00	£17,616 16 3	100.00	£17,760 2 11	100.00

livestock on one farm, compared with 90 % on one of the sheep farms. It is true that the considerable difference between the proportion of arable to the total area prevailing between Groups 1 and 2 will tend to suppress in comparison the proportion of capital invested in livestock in the former group and enhance it in the latter. But this argument cannot be upheld in comparing Groups 1 and 3, since the proportion of arable in Group 3 is over 26 % of the total area compared with 22.5 % for Group 1, and the wide divergence in the proportion of capital invested in livestock is evidence of deep-rooted differences in the use and distribution of capital.

It follows naturally that the proportion of dead stock capital will be much larger in the case of the first Group of farms than in the others. With an average proportion of 16 % for the three Groups, Group 1 has almost 24 % invested in the first division of dead stock, compared with 15 % and 13 % for the other two groups. The capital equipment invested in this category is necessary to all stock raising farms, since the major part of this equipment consists of food preparing and other equipment necessary for the maintenance of livestock. When, on the other hand, field equipment is considered, arable or pastoral systems will be reflected in the apportionment of capital. For example, the larger proportion of field cultivation implements in Group 3 compared with Group 2 can be attributed to the larger proportion of arable land to the total area of the bigger farms. But the relative position of Group 1 in this matter is unmistakable and points to a handicap of the small farm compared with the larger when the same method of farming is adopted.

Since the economy of dead stock equipment, whether utilised in connection with livestock or field work, is to be largely measured by the amount of work which it is called upon to perform, some illustrations of varying economy will be given in this capital analysis. To some the question will naturally occur whether the unduly large proportion which on the small farm is invested in the indirectly productive form of equipment is compensated for by an increased amount of work performed, or whether it is an inherent weakness in the economy of the smaller farms as at present organised. In some instances it will be necessary for purposes of illustration to rearrange the classification of farms so as to neutralise variations in systems.

In the first place the differences in the utilisation of horse power are shown by the acreage of arable and pasture land, and numbers of livestock for which work has to be done.

TABLE III.

Acres of Arable and Pasture Land and Number of Livestock per Working Horse.

	No. of horses.	Arable Acres.	Pasture Acres.	Dairy Cows.	Other Cattle.	Sheep.	Pigs.
Group 1	12.5[2]	5.92	20.32	3.44	7.52	9.6	2
Group 2	39	7.23	25	3.45	5.7	15.0	2.1
Group 3	28	11.4	24	4.3	8.1	37.4	6
Total and Average	79.5	8.49	23.84	3.75	6.8	22.2	3.4

In almost all cases the amount of work which will be required of each horse, as herein gauged, increases with the size of the farm. The amount of arable land per horse is almost twice as much in Group 3 as in Group 1, and this class of land constitutes by far the most important demand for horse labour. The tendency noticeable here is brought out more clearly in the following table, showing crop areas per horse on the basis of the 1920 crop area.

TABLE IV.

Crop Acreage per Working Horse. 1920.

	Hay. Acres.	Cereals. Acres.	Roots and Greens. Acres.	Total Acres.
Group 1	7.31	4.26	1.2	12.8
Group 2	7.45	5.41	1.53	14.39
Group 3	7.7	7.9	3.05	18.65
Averages	7.51	6.11	2.02	15.67

In connection with Tables III and IV it should be remembered that Groups 1 and 2 each contained one tractor and that Group 3 contained three tractors.

The greater economy of horse labour on the larger farms as demonstrated here, should contribute towards making the unit cost of horse labour less on the larger than on the smaller farms, since the scope is wider for each horse, and it is known that normally the cost of horse labour per day falls as the number of days worked in a year increases. Thus it appears that the horses on the smaller farms will be less productive *through their work* than those on the larger farms. It may possibly be true that the land of the small farms is more intensively cultivated and yields heavier crops, or that the stock of the smaller farms is more productive than that of the larger farms; but unless this is the case the indirect product of horses must be less and labour must be more expensive. But there is the other alternative, that the direct production of horses may be greater on the small farms by the greater production and sale of horses themselves. The probability is that at present neither of these

[2] Fractions are the result of taking the mean number throughout the year.

alternatives reduce the cost of horse labour on the small farms to the level reached on those which are larger. This is not a new discovery, for it was stated in what was known as "Arthur Young's law": "Ploughing necessarily costs more on the small than on the large farm."[3] But the fact needs reinforcing, especially in relation to conditions in Wales.

Similarly, in the case of dead stock equipment, the heavier relative equipment of the small farms must either be more intensively employed per acre of land, for the purposes of obtaining higher yields, and more intensively used in the production of livestock for getting higher yields; or it must be relatively less productive than on the larger farms. The chief final sale products of Welsh farming are of livestock and their products; and if the value of dead stock and fixtures (the indirectly productive equipment) per £1 invested in livestock is shown a measure of the greater intensity of use required to equalise productivity of the smaller and larger farms will be obtained.

Investment in Dead Stock.
Per £1 invested in Livestock.

	s.	d.
Group 1 (under 100 acres)	13	9
Group 2 (101—200 acres)	7	2
Group 3 (201 acres and over)	6	7
All Groups	7	9

In so far as crops are produced for direct sale on the small farms this comparison is invalid, but as a matter of fact crops for direct sale tend to be more common on the larger farms; and the measure, though not strictly accurate, is useful. It shows that equal productivity of dead stock equipment in the group of smallest farms would require about double the intensity of use obtained on the larger farms. The working horses have been included with livestock in the comparison, but if they were added to the dead stock equipment as being only indirectly productive the comparison would be worse for the small farms. Thus the conclusion that dead stock is less productive on the smaller farms can fairly be stated.

If the grouping of farms by range of size is relinquished and other methods of grouping adopted, further illustrations of the economy of equipment can be drawn from an analysis, as in the case of the value of field implements and machinery per acre of crops. Since the major part of the field equipment is devoted to cultivating and harvesting arable crops the hay acreage will be omitted. In the following table is given the total cereal, roots and green crop area,

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[3] Levy, "Large and Small Holdings," pp. 19 and 62.

and the value of cultivation equipment together with corn harvest machinery and a proportion of the "general" field implements, such as horse rakes and small tools—which are used in both hay and corn harvests. The farms are now *grouped according to the area under arable crops.*

Distribution of Cultivation and Corn Harvest Equipment per acre of Arable Crops, 1920.

Group.	Farms growing	Total acreage crops.	Value of Equipment.	Value per acre.	Less Tractor.
		a. r. p.	£ s. d.	£ s. d.	£ s. d.
A. 6 Farms.	15 acres and less	40 0 0	493 3 6	12 6 7	7 6 7
B. 7 Farms.	16—30	157 1 31	646 13 4	4 0 10	3 5 1
C. 8 Farms.	31 and over	448 0 0	1,654 7 0	3 13 10	2 14 3
Totals and Averages 21 Farms		645 1 31	2,794 3 10	4 6 8	3 2 4

With the increase in the crop area there is a significant and unmistakable fall in the value of equipment per acre. On the farms with the small crop areas the distribution is over three times as much as on the two other groups of farms. It is not known whether in these cases of small crop areas there was any attempt to reduce the burden of heavy overhead charges in this aspect by hiring out part of the equipment. Unless some such thing is done or cultivation is very intensive, it seems evident that much of the field equipment capital on the farms with small crop areas is relatively unproductive and can earn but a very low rate of interest. Moreover, it can be suggested that the risk involved by the smaller farmer in investing in such long period capital is greater than in the case of the large farmers, since the longer period which such outlay requires to repay its cost opens the road to what may be violent and disastrous changes in the price level.

Uneconomical use of equipment is not by any means confined to the small farm, for on larger farms a single department which is small in itself may be uneconomical in the use of capital. Thus a cream separator which costs £16 may be used for the milk of four cows on a farm of 150 acres, while on a farm of fifty acres a similar machine may be used for the milk of ten cows. But, eventually, the economy of a certain equipment and a certain method can only be determined by the consideration of alternatives. Still, individual

farms can be taken to show the varying amounts of work which are demanded from certain implements. On five of these twenty-one farms tractors varying in value from £95 to £180 were kept, and the crop area per tractor is shown in the following table. Since tractors do some amount of belt work, such as chaffing and grinding, the number of horses and cattle on the farms is also given.

TABLE V.

Crop Acres and Livestock per Tractor on Five Farms.

Farm No.	Total Area. Acres.	Hay. Acres.	Cereals, Roots and Green Crop. Acres.	Average No. of All Horses.	Average No. of Cattle.
1	41	16.5	12.5	3.5*	15
16	165	35.5	25.75	8.5	46.5
17	200	39.5	90	20	97
18	223	41.75	54.2	10.5	57.5
21	297	44.75	108	11	77.5

* N.B.—The fraction is the result of taking the average number of horses and cattle through the year. The number of *working* horses, in addition to the tractor, for each farm is (1) 2.5; (16) 3.5; (17) 9.5; (18) 4.5; (21) 7.5.

The maximum work requirement of the tractors on each of these farms varies very considerably, and it is not difficult to gauge the economy of tractors on each of these farms.

Divergences, though not so extreme, are to be seen in the acres per binder and mower on some farms. These are implements which can be used for only one purpose, and their employment is absolutely seasonal, so that it is important to obtain the maximum return from them during the hay and corn harvest.

TABLE VI.

Hay and Cereal Area, and Number of Mowers, Reapers and Binders on Nine Farms.

Farm No.	Total Area.	Hay Acreage.	No. of Mowers.	Cereal Acreage.	No. of Reapers.	No. of Binders.
3	70	10.75	1	17.25	—	1
4	73	28.25	1	7.5	1	1
11	140	33.0	1	27.0	—	1
12	140	37.0	2	28.8	—	1
13	152	27.5	2	16.5	—	1
16	165	35.5	1	16.75	—	1
17	200	39.5	2	63.	1	1
18	223	41.75	2	45.75	—	1
21	297	44.75	2	77.5	—	1

On farm No. 4, for example, it is doubtful whether the economy of labour derived from the binder is sufficient to cover the capital expense, especially when it is noted that on this farm there was also one reaper. Only 7.5 acres of cereals were grown, compared with the

77.5 acres which the only binder on farm No. 21 was called upon to harvest.

Generally speaking, there is a clear relation between the distribution per acre of field equipment and the area over which it is distributed; the smaller the area, the more will be the value per acre of field equipment.

A similar relation can be traced in that between the size of the herd of dairy cows and the value per head of dairy equipment. This is illustrated in the following table, in which the farms are classified on the basis of the size of the herd, there being no necessary correlation between the size of the herd and that of the farm.

TABLE VII.

Value of Dairy Equipment per Cow in Herd.

	Herds with	No. of Farms.	Average No. of Cows during year.	Dairy Equipment. Total Value.	Dairy Equipment. Value per head.
				£ s. d.	£ s. d.
Group A.	1—8 cows.	7	49	136 15 9	2 15 11¾
Group B.	9—16 cows.	8	83	188 11 7	2 5 5¼
Group C.	17 and over.	6	166.5	221 14 10	1 6 8
Totals and Averages			298.5	547 2 2	1 16 8

For the three groups the graduation of the value of dairy equipment is in accordance with general principle.

Food preparing machinery is used more or less for all the stock on the farm, but it is used very little for sheep and, unless grain is ground on the farm, very little for pigs. Its chief use is in the preparation of food for cattle and horses. Therefore, in preparing a comparison of the value of food-preparing equipment in relation to the livestock of farms, pigs and sheep have been excluded, and also calves and foals. Although the equipment may be put to some uses connected with these classes of stock, the total use on any farm for this purpose would be very little. The specialised "sheep equipment" is treated separately. Taking working horses, other horses (except foals), dairy cows and all other cattle (except rearing calves), a comparison of the value of food preparing equipment per head of stock is shown for three groups of farms, grouped according to the acreage basis used for earlier comparisons. The average value per farm is also given.

TABLE VIII.

Value of Food Preparing Equipment per head of Cattle and Horses (excluding Calves and Foals) and Value per Farm.

Group.	Acres.	Numbers of Larger Stock. Cattle.	Horses.	Total.	Value of Food-Preparing Equipment. Total.	Per Head	Average No. of Cattle and Horses per Farm.	Average Value F.P.E. per Farm.
					£ s. d.	£ s. d.		£ s. d.
1	1—100..	114	20	134	578 10 3	4 6 4	26.8	115 14 0¼
2	101—200..	313	77	390	1,011 16 1	2 11 7	35.4	91 19 8
3	201 & over	265	54	319	613 10 0	1 18 5	63.8	122 14 0
Totals & Averages		692	151	843	2,203 16 4	2 12 2	40.14	104 14 0

The same relation between the numbers of livestock and the value of equipment per head is again evident. Similarly, for the three groups the value per head of sheep equipment is respectively 2s. 10d., 1s. 3d., 1s. 2d., with an average value of 1s. 3¾d.

The salient fact emerging from these illustrations is that the small crop area, the small herd, and the small flock is burdened with a high unit cost of capital equipment, and that the high proportion of capital invested in dead stock on the smaller farms is not compensated for by a greater economy in use. This consideration, together with the known relation between the economy of labour and the size of units whether of crops or stock, must be borne in mind in any attempt to arrive at the " economic unit " in farming. Some form of joint ownership of field equipment should recommend itself to small farmers as a means of mitigating the heavy capitalisation which is an uneconomic feature of the smaller farms as organised at present.

RESEARCH WORK IN ANIMAL BREEDING AT THE COLLEGE FARM OF THE UNIVERSITY COLLEGE OF NORTH WALES, BANGOR. II.

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In the last volume of this Journal (pp. 33-38) a short account was given of the research work on Animal Breeding in progress at the University College, Bangor. During the past year the work has been continued under the various heads mentioned, as well as in one or two new directions.

I. Wool Improvement in Welsh Sheep.

It was pointed out in the previous article that the improvement of the wool of mountain sheep must be effected without impairing hardiness and mutton qualities, and that the variations which exist in Welsh wool make the prospect of improvement by selection within the breed very hopeful. Any practical scheme must take into account all the factors involved—the manufacturer desires absence of kemp and fineness of fibre—the breeder desires a thick coat at birth and a dense weather-resisting adult fleece. It is necessary to see how far these requirements can be harmonised, and the all-important quality of hardiness retained, and at the same time to interpret the important characteristics in strict scientific terms so as to form the basis of accurate experimentation.

A considerable advance has been made in the direction of a closer analysis of the fleece from a practical point of view; there is every indication that the problem will be greatly simplified thereby.

In order to give definiteness to the breeder's opinion of the fleece a score-card has been constructed as follows by Professor White and Mr. R. N. Jones.

1. Absence of Kemp—Full marks, 10.
2. Length—Right length, 10. Fleeces which are too short, 9, 8, etc.; those which are too long, 11, 12, etc.
3. Density—Full marks, 10.
4. Absence of Lockiness—Full marks, 10.
5. Fineness—Full marks, 10.

It will be noted that this is not a score-card in the ordinary sense of the term. It is not intended to use it for obtaining a figure of excellence for individual sheep as the points are not of equal value, and in respect of the first point the optimum is a matter for argument. From the point of view of the breeder, who desires a weather-resisting coat, points 2—4 are the important ones. A large number of sheep have been graded in this way.

Last autumn, about 180 wether lambs, whose coats at birth were known, were graded by Professor White and Mr. Jones. An analysis of the figures obtained has proved extremely valuable. It might be pointed out that several factors contributed to the accuracy of the figures obtained.

1. The lot was uniform with regard to age and sex.
2. All the grading was carried out on the same day.
3. The possibility of unconscious bias was eliminated because no

one had any idea that the figures would be used in the way that was afterwards adopted, and in addition neither Professor White nor Mr. Jones knew what the marks meant which indicated coat at birth.

This question of the type of coat at birth is of considerable importance. The results of the examination of new-born lambs recorded in the previous article are therefore recapitulated. The coats at birth of Welsh lambs fall into three well-defined classes:—

I. Thick hairy coat all over the body.

II. Fine curling wool of the Down type on the shoulders or forepart only, the rest of the body being covered as in I.

III. Fine curling wool all over.

Type III, and the finer varieties of Type II, are regarded by breeders as unsuitable for extreme mountain conditions.

The figures obtained from the grading of the coats of the 180 sheep have been analysed from two points of view—first to determine the degree of correlation, if any, between each of the five points and the other points in each case, and secondly the relationship of the values obtained for each point and the type of coat at birth. The results of this analysis are briefly noted below:—

1. The proportion of kemp was not correlated with any of the other four points.

2. The four points, shortness, density, absence of lockiness, and fineness, were all fairly closely correlated with each other.

3. The sheep which possessed a Type III coat at birth (fine curling wool all over) possessed on the average the best adult coat in respect to all the five points. Type II sheep (fine wool on forepart of body) came next; Type I (thick coat all over) being the poorest. The figures are shown in the following Table:—

Type of Coat at Birth.	No. of sheep.	Absence of Kemp.	Length.	Density.	Absence of Lockiness.	Fineness.
I.	52	6.50 ± 0.12	11.11 ± 0.12	7.73 ± 0.14	6.80 ± 0.15	7.00 ± 0.12
II.	97	8.06 ± 0.07	9.87 ± 0.09	8.15 ± 0.10	7.13 ± 0.10	7.96 ± 0.09
III.	30	9.47 ± 0.09	10.31 ± 0.07	8.77 ± 0.13	7.77 ± 0.12	8.97 ± 0.11

4. Although the above results are true as regards the *average*, individuals are found which have a thick coat at birth and yet possess

an excellent adult coat. Out of the fifty-two sheep examined which had a Type I coat at birth those which showed:—

Absence of Kemp, 8-10—numbered 14.

Length, 10	numbered 12.
Density, 9-10	
Absence of lockiness, 8-10	
Fineness, 8-10	

Those which came up to both the above standards numbered six.

It remains to be seen how these results fit in with the examination of Welsh fleeces by the manufacturing expert. The Department is greatly indebted to Mr. James Briggs, of Bradford, for his assistance in this matter. Mr. Briggs classified all the pedigree fleeces of the College flock (1924 clip). The manufacturer's point of view can be briefly indicated. Welsh wool of good quality comes into the Down class, so every improvement just carries it higher in the class it is already in. There is no question of having to find fresh markets. The grading depends on two main points only:—

1. The proportion of kemp.
2. The fineness of fibre (other than kemp).

Mr. Briggs confirms the close correlation between shortness of fleece and fineness noted above.

A consideration of the above facts leads to the following conclusions:—

1. Selection for less kemp will not affect the adult coat in any other direction.

2. The manufacturer wants fineness which is correlated with shortness of fleece; so does the breeder within reasonable limits.

As far, then, as the adult coat is concerned, wool improvement is almost entirely a matter of selection for these two points—absence of kemp and shortness of fleece. As regards the very important qualities of density and absence of lockiness it does not seem necessary to bring them specifically into the scheme. The breeder will always consider them in any case; moreover, in selecting for a short fleece they will be automatically improved to a certain extent.

It is, however, certain that if selection on the above lines were to be carried out regardless of anything else, the lamb's coat at birth is going to suffer. The breeder is strongly of the opinion that a thick coat is necessary for extreme conditions; it seems hardly necessary to

test this belief because the breeder is very probably right; also it would be a difficult matter to test, and, even in the very unlikely event of the breeder not being right, it would be difficult to convince him to the contrary.

The solution is indicated above. It is possible in general to secure improvement in two ways—first by eliminating the hairy coat of the lamb (as in the Southdown), or alternatively *by developing a type in which the thick lamb's coat is shed instead of persisting.* An analogy is seen here in the case of several breeds; e.g., in certain strains of Merinos the lambs have a thick, very coarse coat which is completely shed, leaving a very fine and superior adult fleece. The Black Welsh breed too produces wool which is relatively free from kemp, and yet the lambs have particularly thick coats at birth. All the above types occur in the Welsh breed, and if the gap between pedigree and mountain breeders is to be closed up it is absolutely essential that fineness must not be obtained by sacrificing the lamb's coat; the movement in this direction, if it exists, can only work harm to the interests of the breed.

It is now possible to lay down an ideal specification for the fleece of Welsh Mountain sheep.

1. A thick coat at birth.
2. Kemp reduced to a minimum.
3. Shortness of fleece (and thus, automatically, fineness).

This is by no means an impossible standard; sheep conforming to it probably exist in almost every flock, and attention to these simple points alone should bring Welsh wool almost into the Shropshire class.

Weight of fleece is an important consideration. The finest Merino wool is found not to be profitable in Australia because it is impossible to get sufficient wool per sheep. It is the value of the wool clipped per sheep, not its price per pound, that counts. While quality is being improved, therefore, quantity must be maintained or increased. The reduction in the length of staple of Welsh wool would, in all probability, be counterbalanced by increased density, but this point must be watched.

Some breeders will believe that, provided the thick lamb's coat is retained the elimination of kemp will not affect hardiness, but it is possible that some will still consider that there is some other and obscure connection. This can be tested by using specification sheep on the mountain; in any case a direct test is desirable.

Arising from this work a number of problems stand out; they are being investigated at present. For example:—

1. Is it admissible to allow a type of lamb with just a little fine wool on the shoulders, not enough to give the lamb a bad coat? The answer depends entirely on whether such a sheep will tend to throw finer-coated lambs, and this can easily be ascertained.

2. What is the relative importance from the manufacturer's point of view of the two points, kemp and fineness?

3. Would a strain of sheep with thick coats at birth breed true? —and so on.

From the more strictly scientific point of view it is very necessary to have accurate measures for those characteristics that are found to be important. As was described in the last volume of this Journal, a method has been worked out for obtaining definite figures for the proportion of kemp. and the values thus obtained appear to be capable of yielding useful results. In the same way a method is being elaborated for obtaining a measurement of length. This work will be especially useful in connection with investigations into the mode of inheritance of fleece characters, upon which subject a considerable body of data is available in the College Flock-book, and will be made available in *ad hoc* experimental breeding.

II. Colour Inheritance in Sheep.

In the last volume of this Journal experiments with "badger-face" and with Black Welsh Mountain sheep were described. In the first season's experimental breeding a badger-face ram mated to badger-face ewes gave only badger-face lambs, the same ram giving with white ewes sixteen whites and two badger-faces. This is to be expected if badger-face pattern behaves as a simple recessive, because badger-face lambs do sometimes occur in the flock from which the white ewes were obtained. The white ram used, when mated with badger-face ewes gave six badger-faces and one white. If the white ram were heterozygous for the pattern the expectation would be half whites and half badger-faces. Although the divergence is not very large for such numbers it was thought advisable to test a badger-face ram from the last mating with badger-face ewes. He gave nothing but badger-faces. It has been found that the white ram used in the experiments sired a badger-face lamb in 1921, and another in 1924, while a son of his sired five such lambs in 1924. The evidence is

now fairly complete that this pattern behaves as a simple recessive; an F_2 generation will, however, be raised.

Black colour in Welsh sheep appeared to be a simple dominant; it is hoped to raise an F_2 in this case too.

Black × badger-face matings gave black lambs. A black ram from this mating crossed to badger-face ewes gave eleven blacks, four badger-faces and three whites, which is fairly close to the ideal 2 : 1 : 1 ratio. This result shows that in the original cross two factors were involved. Half of the eleven blacks would be expected to be homozygous for the badger-face character, but all were quite undistinguishable from the ordinary Welsh black sheep. This is an example of what is sometimes called "epistasis." The constitutions which in the absence of the other would give respectively black and badger-face are both present, but only the epistatic factor—black—is expressed.

Several reversed badger-face sheep have been acquired, and are described elsewhere in the present volume.

Piebald (Spanish, Syrian) sheep crossed to any other breed give nothing but whole blacks. Major Platt, after verifying this statement in the case of Southdown and Welsh crosses, carried the experiment a stage further. A black F_1 ram mated to white ewes gave six whites to five blacks, so that in a cross with Piebald sheep a dominant black factor is involved as well as (probably) a recessive pattern factor which, acting in the presence of black, gives the piebald pattern.

The results of the crossing experiments with Piebald sheep are also dealt with in a separate article.

III. Congenital Abnormalities.

Some progress has been made with the problem of the limb-defect in new-born lambs mentioned in the last volume. There are indications that it may prove to be a simple recessive and will thus be inherited in precisely the same way as the badger-face pattern.

For the benefit of those who are unfamiliar with the facts of Mendelian inheritance it may be useful to give a very brief explanation. Taking, for example, badger-face pattern, badger-face sheep crossed to whites give white lambs. The badger-face character is therefore spoken of as *recessive*, the contrasting white being *dominant*. If these first crosses are interbred the result is three whites to one badger-face, i.e., three dominants to one recessive. The original parents, whites and badger-faces, are called the P_1 generation, the first cross being the F_1 generation, and the second

cross obtained by interbreeding the F_1 is the F_2 generation. The explanation is as follows. The whites and the badger-faces possess *factors* for white and badger-face respectively, and when they form eggs and sperm something representing these characters is included in these cells.

Let the factor for white be F.
Let the factor for badger-face be f.

The white parent contributes F and the badger-face f. The new individual resulting from the union of egg and sperm will be Ff, but will be white in colour because white is dominant. When the F_1 individual comes to form its germ-cells, eggs or sperm as the case may be, F and f separate once more, that is, half the germ cells will contain F and half f. If the sheep of this constitution are interbred, the sperm may be F or f, and the eggs may be F or f. The result of chance matings is 1FF; 2Ff; 1ff; i.e., three whites (one only will breed true) to one badger-face. It will be seen why whites may throw badger-faces while badger-faces mated together will give nothing but badger-faces.

If whites which carry the badger-face character, i.e., having the constitution Ff, are *back-crossed* to the recessive, i.e., badger-face, ff. the result is:—

White parent.	*Badger-face parent.*
F or f.	f.

giving 1 Ff and 1ff, *or* equal numbers of whites and badger-faces.

It may also be useful to consider the methods a breeder might adopt if an abnormality of this sort occurred in his stock. First of all, for the production of the abnormality, *both* parents must carry the factor for the defect, so that ram and ewes are equally to blame. It is possible to test a ram; this would involve crossing him to a number of ewes known to carry the factor. If he gave even one deformed lamb he would be known to be heterozygous for it. If a considerable number of lambs were bred the proportion of abnormal lambs would be one in four. It is hardly possible to test ewes in the same way, and probably the most practical means for reducing the proportion of affected lambs would be to discard at once any ram or any ewe which gave one, and if a ram were used which did not sire any affected lambs from a flock where the defect was known to occur he should be retained as long as possible. In this way the incidence of the abnormality would be rapidly reduced.

PIEBALD (SPANISH) SHEEP AND THEIR CROSSES WITH OTHER BREEDS.

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The origin of the Piebald breed of sheep is very obscure. They have been variously described as Spanish, Syrian, Portuguese, African, Persian, Zulu, Egyptian, and Barbary. The late Mr. Noble, who had a large flock of these sheep, made a detailed study of the history of the breed; an account of his investigations was published privately, but a shorter account by him is included in Elwes's "Guide to the Primitive Breeds of Sheep and their Crosses" (1913). It may be stated briefly that it is certain that Piebald flocks have existed in Great Britain for a considerable period, and pictures of the breed at Tabley House and at Wentworth, painted about 1760, show that there has been little, if any, change in appearance since that date. It is also practically certain that the breed no longer exists outside England, painstaking efforts to trace it in other lands having failed. From the conflicting information available it appears to be at least a possibility that the home of the breed was Northern Africa, from which it could readily have spread to Spain with the Moors, while the ease with which South African sheep of similar but not identical characterisation were absorbed into certain flocks during the last century makes it possible that some degree of relationship existed.

The sheep in the majority of flocks are four-horned, but some flocks consist only of two-horned individuals, this characteristic being carefully preserved in these cases. It is possible that the breed was originally two-horned, and that the four-horned character was introduced by crosses with other primitive breeds.

Though the breed is mainly an ornamental one, it possesses many excellent qualities, and according to Wallace (1923) there are probably 150 flocks in existence in Great Britain at the present time. They are hardy, prolific, and make excellent mothers. Portal (1923) states that his lambing results were:—

1921—61 lambs from 34 ewes.
1922—88 ,, ,, 50 ,,
1923—87 ,, ,, 47 ,,

In Major Platt's flock this spring twenty-six ewes produced fifty lambs. The sheep are little affected by lameness. The lambs fatten quite readily and the mutton is of very superior quality.

In this paper attention will be confined to the inheritance of colour in crosses of Piebald sheep with other breeds. The experiments to be described were carried out by Major E. J. W. Platt, of Gorddinog, Llanfairfechan. This flock was founded by the late Colonel Platt, who acquired the sheep from a flock the origin of which is unknown. Owing to the attention given to the breeding of the sheep, with an exchange of rams from time to time, a very successful type of sheep has been developed and maintained. Plate I, Fig. 2, shows the average amount of spotting, Figs. 3 and 4 the lightest and the darkest lambs born in Major Platt's flock in 1925. There does not appear to be any marked correlation between the amount and nature of the spotting in parent and offspring. The writer has made enquiries with a view to ascertaining whether lambs are ever produced other than piebald and can discover no record of such occurrence; Piebald sheep would appear to breed quite true.

One of my correspondents writes: ". . . . the farm steward tells me . . . he has *never* seen one of the sheep wholly black or wholly white." This reply to my queries is typical of several.

There is little tendency for the spotting to assume any particular pattern, the only approach to a constant feature being the concentration of pigment round the neck, the black area usually involving both eyes and leaving a clear strip of white down the centre of the face. This feature, however, while usual, is by no means invariable, as is seen in the case of the ewe in Plate I, fig. 3. At birth the pigmented areas are quite black, but this colour soon becomes transformed into a fawn.

It has been recorded by several writers that the crossing of Piebald sheep to any other breed gives self-black lambs only. Among the breeds mentioned in this connection are Wiltshire, Border Leicester, Hampshire, Cheviot, and also the wild Mouflon.

It is, however, found that " white pattern," viz., a white spot on the top of the head and a white tip to the tail, occurs in some cases (fig. 4, Plate II). This feature has been recorded by the writer in crosses with Welsh Black sheep (1924), by Elwes (1913) in Manx sheep, and by Wallace (1915) and Adametz (1917) in Karakul sheep and their crosses. Adametz considers that this characteristic depends upon a single recessive factor together with an additional factor modifying the action of the main factor.

In the autumn of 1923 Major Platt made reciprocal crosses between Piebald sheep on the one hand and Southdown and Welsh sheep on the other. The previous results were confirmed, the lambs from the four matings being black. One or two of the Southdown crosses and all the Welsh crosses showed white pattern. In one or two cases this was fairly extensive, little tufts of white being scattered over the forepart of the body. These tufts would in all probability only exist in the lambs' coat. At Acton Reynauld in the same season a Piebald ram was mated to fifty Kerryhill ewes. Again all the lambs were black and in this case only six showed sufficient white pattern for the fact to be noted. Plate II, fig. 2, shows some of these lambs. At Overbury Court crosses with Oxford Downs have been made in previous years with precisely similar results.

In the case of Major Platt's flock the experiment was carried a stage further. A black Piebald × Southdown ram (Plate II, fig. 1), was mated up to Welsh Mountain ewes. The results are shown in the following table:—

Ewe.	Sex of lamb.	Phenotype of lamb.	White Pattern.
1	Male.	White.	—
1	Female.	White.	—
2	Male.	Black.	None.
3	Female.	Black.	White tuft on head only.
4	Male.	White.	—
5	Male.	White.	—
5	Male.	Black.	White tuft on head only.
6	Female.	Black.	White tuft on head only.
6	Female.	White.	—
7	Female.	Black.	White tuft on head only.
7	Female.	White.	—

Segregation was perfect, as will be seen in Plate II, fig. 3.

The results show clearly that Piebald sheep possess a dominant black factor as contrasted with ordinary white sheep. The F_1's are all black and the backcross to the recessive white gave six whites to five blacks, practically an ideal ratio.

As regards the spotting, the simplest assumption is that Piebald sheep are homozygous for a recessive piebald factor which acts on the dominant black, restricting the pigment to certain areas. It is hoped to test this hypothesis this season by mating a black F_1 ram to Piebald ewes. This mating will also be a test for another possibility. It is remarkable that F_1 lambs do not lose the black colour. While it would be anticipated that the bleaching of black wool to a brown

DESCRIPTION OF PLATES.

PLATE I.

Fig. 1. Typical Piebald head (ewe).
Fig. 2. Piebald ewe and lambs; average amount of spotting.
Fig. 3. Lightest lamb born at Gorddinog, 1925.
Fig. 4. Darkest lamb born at Gorddinog, 1925.

DESCRIPTION OF PLATES.

Plate I.

Fig. 1. Typ[illegible] (EWE).
Fig. 2. Piebal[illegible] [illegible]ops, average amount of spotting.
Fig. 3. Lightest [illegible] at Gorddinog, 1925.
Fig. 4. Darkest lamb [illegible] at Gorddinog, 1925.

PLATE II.

Fig. 1. PIEBALD × SOUTHDOWN RAM USED FOR BACKCROSS.
Fig. 2. PIEBALD × KERRYHILL LAMBS (ON RIGHT).
Fig. 3. WELSH EWE WITH LAMBS FROM RAM SHOWN IN FIG. 1.
Fig. 4 BLACK LAMB FROM ABOVE CROSS, TO SHOW "WHITE PATTERN" ON HEAD.

colour is usually dependent on several modifying factors, or is even largely non-genetic, the clear-cut distinction in this particular case between the pure Piebald lambs and the F_1's makes it conceivable that a simple relation exists.

I wish to express my thanks to Major E. J. W. Platt, of Gorddinog, Llanfairfechan, and to his farm manager, Mr. Coward, for the facilities for observation they have placed at my disposal, for the information they have given me, and for so readily consenting to carry the experiment further. My thanks are also due to Mr. R. Holland Martin, Overbury Court, Tewkesbury, and to Sir Gerald Corbett, Bart., Acton Reynauld, Shrewsbury, for allowing me to inspect their flocks. I am indebted to Mr. Hall, of College Hill, Shrewsbury, and to Mr. Holland Martin, for much useful information.

Summary.

(1) The Piebald breed is briefly described, chiefly from the point of view of pigmentation.

(2) The results of crossing this breed with other breeds are recorded.

(3) It is shown that the production of whole blacks in the F_1 generation of any cross is due to the possession by Piebald sheep of a dominant colour factor (which is possibly associated with a recessive piebald factor).

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A PRELIMINARY NOTE ON REVERSED BADGER-FACE PATTERN IN SHEEP.

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Badger-face pattern in Welsh sheep was recently described by one of the present writers (1); it has also been described in the sheep of Western Norway by Wriedt (2); and the occurrence of a lamb with typical badger-face markings has been recorded by Heller in a Rambouillet flock (3). The pattern is found in Cheviots, in Shetlands, and in the sheep of Barbados.

The existence of Welsh sheep possessing a "reversed" badger-face pattern in which the characteristic black areas of the badger-face are white and vice-versa was noted in the paper mentioned (1), but at that time the writer had only seen sheep in which the reversal was indefinite and poorly defined. Several sheep have recently been acquired in which the pattern exhibits a clear reversal, the whole effect being so striking that it has been thought worth while to place a description on record, although data on the mode of inheritance of this new pattern are as yet scanty.

Three ewes are selected for description. Figs. 1—4 are of Ewe No. 1; Fig. 5 shows the head of Ewe No. 2, and figs. 6—8 are of Ewe No. 3.

The ordinary badger-face pattern is subject to extreme modification, and it is only the existence of a very complete series of intermediate types that enables one clearly to recognise the identity of the pattern in various cases. In spite of this variation the presence or absence of badger-face pattern depends upon a single recessive factor. In view of these facts there would be every reason to anticipate a similar series of wide modifications of the reversed pattern also; this is actually the case.

The following table gives the salient features of the typical badger-face pattern and the nature of the corresponding areas in the three ewes with the reversed pattern:—

DESCRIPTION OF PLATE.

Figs. 1–4. Reversed badger-face ewe No. 1, see text.
Fig. 5. Reversed badger-face ewe No. 2, see text.
Figs. 6—8. Reversed badger-face ewe No. 3, see text.

TABLE.

Typical Badger-face.	Reversed Badger-face No. 1.	Reversed Badger-face No. 2.	Reversed Badger-face No. 3.
Two black bars between eyes.	Two white bars between eyes.	Two white bars between eyes.	Two white bars between eyes.
Black muzzle (variable).	A little white on muzzle.	White on muzzle.	White muzzle.
Very characteristic black area involving lower jaw.	Precisely same area but white.	Precisely same area but white.	Same white area but not well defined.
Outside of ears white, inside black.	Outside of ears black, inside white.	Outside of ears black, inside white.	Indefinite.
Ventral surface black.	Ventral surface white.	Body markings indefinite grey and white.	Ventral surface white.
Legs black with very characteristic light curved areas on outer surface.	Legs light with the same curved areas black.	Legs white with same curved areas grey.	Legs light with curved areas darker. Indefinite.
Black area spreads out over flanks on each side of tail.	White area spreads out over flanks on each side of tail.	Indefinite.	White area spreads out over flanks on each side of tail.

It will be noted that as regards the head, No. 2 shows the most accurately reversed areas, though in this sheep the body areas are very poorly defined. In No. 1 the reversal as a whole is very good. No. 3 is rather smudgy, but the ventral area is excellent: the colour, too, is brown rather than black; on the whole, the most persistent and characteristic area in the case both of badger-face and the reversed pattern is that involving the lower jaw.

A rather remarkable similarity exists between the reversed badger-face pattern and that found in many Soay sheep; it is hoped to put this matter to the test of direct experiment.

The distribution in Welsh flocks of sheep exhibiting this pattern is of some interest. In contrast to ordinary badger-face pattern, which is relatively common, it is rare. Most of the sheep of this type that we have seen have come either from one individual flock or from neighbouring flocks which might be expected to have been affected by the original flock. As regards the flock in question reversed

badger-face blood was introduced about forty years ago by the purchase of ewes from a flock some distance away. Under the impression that this strain is particularly hardy the owner has practised a certain amount of line breeding while at the same time there has been a gradual infusion of the strain into his stock as a whole. However, only in 1924 has a reversed badger-face ram been used and then only to a strictly limited extent.

The evidence concerning the mode of inheritance of the pattern is scanty, but such as exists points to a single recessive factor; there are also indications that in inheritance it is quite independent of badger-face pattern and of black colour.

(1) Reversed badger-face lambs appear from white to white matings.

(2) Reversed badger-face ewes mated to white rams have within our own observation given white offspring in two cases. In one case the ram was a Southdown, in the other a Welsh Mountain.

In the flock already mentioned a reversed badger-face ram mated to white ewes of the strain from which reversed badger-faces appear gave ten whites and five reversed badger-faces.

(3) In the above mating no other colour or pattern appeared. The owner of the flock states that only whites and reversed badger-faces have appeared in matings of white rams and reversed badger-face ewes and all the reversed badger-faces he has obtained were produced either from white × white or white × reversed badger-face matings.

Our acknowledgements are due to Mr. M. G. Jones, B.Sc., of the Welsh Plant Breeding Station, who was instrumental in obtaining one of the ewes, and to Mr. M. B. Jones, Cyneiniog, for the information given about the breeding results in matings of these sheep.

Summary.

(1) Reversed badger-face pattern is described especially as regards its contrast to badger-face pattern.

(2) Preliminary data are presented which tend to show that the pattern behaves as a simple recessive in contrast to white, and the probability that it is unrelated in inheritance to badger-face pattern and to black colour.

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BLUE-GREY CATTLE.

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The merits of the well-known class of commercial cattle called Blue-greys have long been recognised by feeders and butchers in many parts of this country other than the north of England and the south of Scotland where they are mainly bred. What is generally understood by "blue-grey" when the term is used in the trade, even when it is not specifically denoted as "Scotch," is the first cross between a white Shorthorn bull and a black Galloway cow Generally, too, the calves so bred are reared on their dams out at grass on the poorer kinds of land and often at surprisingly high elevations. Calves reared in this manner and under such conditions, and not separated from their dams until they are five or six months old, prove remarkably good feeders at a later age and finish up with a carcase that ranks with the best. It is because of this that the Blue-grey has secured its reputation, which is, and has been for many years, as firmly established as it is well-deserved. But, as with all classes of live stock, there are degrees of superiority even among what is generally so superior a class of cattle as Blue-greys. Much depends on the judgment that has been exercised by the breeder in the selection of sire and of dams. So wide-spread, however, is the reputation of the Blue-grey, which is known to be the product of cross-breeding, that cattle of a blue-grey colour, whatever their origin, will often find readier buyers than any other lots in the market. The reason, no doubt, for the popularity of the colour is that it is associated in the minds of dealers and feeders

with a method of breeding that is known to produce thriving and profitable stock, and is taken as an indication of much-desired economic qualities in the cattle that show it. Blue-grey is a colour in cattle that is not usually seen except in cross-breds, and cross-bred cattle, not without good reason, are often preferred for certain purposes.

Though "blue-grey" is in the cattle trade used in a specific sense and is applied to the Galloway-Shorthorn cross, as described above, cattle of a blue-grey colour can be produced in other ways. The crossing of Welsh Black cows with a white Shorthorn bull will give blue-grey progeny. Cross-breds of this description are, in fact, frequently found in Wales, being the product of mating ordinary Welsh Black cows with a white, or perhaps more generally, a roan Shorthorn bull. A roan bull will, of course, produce blue-grey progeny from black cows, but cannot be relied upon to do so as a white bull usually can. The breeding of blue-grey cattle by crossing Welsh Black cows is not systematically carried on in Wales as it is done by crossing Galloway cows in the North of England and in Scotland. But blue-grey cross-breds are by no means uncommon, and like the northern blue-greys, though differently bred, they enjoy great popularity as feeders and sometimes also as dairy cattle.

Having seen something of the blue-grey in the North of England and impressed, as a result of inquiry, with the reputation of blue-grey cattle in Wales, it seemed to the writer, then connected with the Agricultural Department of the University College of Wales, Aberystwyth, that in view of the importance to the Principality of its trade in cattle with the great feeding districts of England, a careful comparison between the blue-grey cattle bred in Wales and the true blue-grey, as bred in the North of England and in Scotland, should yield information of at least an interesting, and possibly of a very valuable, kind. Consequently, in 1908, it was decided to arrange a test with this object in view at the then College Farm, for which the writer was responsible. The experiment, more or less as originally planned, was duly carried out, and it is with the results of that experiment, which, for reasons easily explained, were never published until now, that the remainder of this article has to deal.

It must be clearly understood that the object of the experiments here described was to compare the merits of two kinds of blue-grey cattle, bred under exactly the same conditions of land, climate and treatment. The question of relative costs, therefore, although it may be referred to, is not to be taken as a determining factor in so far as the results of these particular experiments are concerned.

In October, 1908, a consignment of ten well-bred, though not registered, yearling Galloway heifers was purchased through a well-known live stock salesman at Castle Douglas, and they arrived in due course at the College Farm. Subsequently four of them were sold and the remaining six were retained for the purpose of the experiment. At the same time six well-bred, but (with one exception) not registered, Welsh Black yearling heifers were bought in the Towyn district of Merionethshire. All the heifers, Galloway and Welsh, running together in one lot, were kept out during the winter of 1908-9, receiving nothing in addition to what they could pick up, except a little hay in the spring of 1909, and no shelter beyond what they could find for themselves. In May, 1909, they were turned to the upper part of the farm, the highest point of which, known as Banc y Foel, has an altitude of about 500 feet, and here they remained throughout the summer. Portions of this land are thin and poor and inclined to run to gorse, but on the greater part there is moderate grass and, except that it is liable to suffer rather badly in a dry season, it is generally very suitable and useful land for young cattle as well as for sheep. It was on this land that the cows used in these experiments were kept during the summer of each year throughout, and it was here therefore that the blue-grey calves were bred.

Experiment I.

The twelve heifers, as far as could be ascertained, were all of very nearly the same age and at the stage where we have now arrived, viz., May, 1909, were slightly over two years old. They had stood the winter well and Welsh and Galloway alike were in satisfactory condition. Each lot was fairly uniform in this respect as well as in type, and for ordinary, commercial cattle they were as representative of their respective breeds as could reasonably be looked for.

A white pedigree Shorthorn bull, purchased from a neighbouring breeder, was turned out to the heifers in the beginning of July and ran with them until the end of October. During the winter following the heifers were kept in the lower and more sheltered part of the farm, but were out all through and treated almost precisely as during the previous winter. They were allowed a little more hay, but did not begin to receive any until January. At the end of April, 1910, they were turned to their summer pasture, which has already been described. At this time the Galloways had a better bloom on them than had the Welsh Blacks and appeared to have stood the winter somewhat better.

The first calf, which was out of one of the Welsh heifers, was born on May 8, 1910, and the last, out of one of the Galloways, on July 27. All the Welsh heifers, except one, which proved barren, calved during May. The Galloways, with one exception, were later in calving, but that is of no particular significance further than that it explains to some extent, perhaps, why the earlier-calving Welsh heifers did not appear in the spring to have stood the winter quite so well as the others. Unfortunately one of the Welsh heifers lost her calf when a few days old. That accident, therefore, reduced the Welsh blue-grey calves to four, another of the Welsh heifers, as indicated, having turned out barren. The dam of the dead calf proved to be a good milker. She was therefore separated from her original companions and kept as a dairy cow with the Shorthorn herd on the farm.

The calves, consisting now of four Welsh and six Galloway blue-greys, ran with their dams and generally throve as suckled calves on grass usually do. They were all blue-grey in colour, though there was considerable variation, some being lighter or more patchy than others. The Galloways showed less variation in colour than did the Welsh, but in neither lot was there any greater degree of variation than is often to be seen among blue-greys. In the Welsh lot there were one male and three females, and in the Galloway lot four males and two females. The bull calves were castrated in September.

The calves were weaned and housed on November 9, 1910. They were fed throughout the winter on chopped straw and hay mixed, pulped roots, and 2 lb. per head per day of a mixture in equal proportions of linseed cake and crushed oats, with an allowance of long hay at night. On May 8, 1911, they were turned out to grass, a particular field having been reserved for them. In this field they remained till September, when they had a field of aftermath, on which they remained till November 9, when they were housed for their second winter. Up to Christmas they were fed on chopped straw and pulped roots, together with hay and 2½ lb. per head per day of a mixture in equal proportions of Bibby cake, undecorticated cotton cake and barley meal. After Christmas linseed cake was substituted for Bibby cake and 4 lb. per head per day of the mixture was allowed. On April 20, 1912, they were turned out to grass and allowed 2 lb. undecorticated cotton cake and 1 lb. linseed cake per head per day. They were so fed until the following July, when they were sold to the butcher at an average age of about two years, and the first experiment came to an end.

No weights were taken until the calves had been weaned and had settled down in the house. From that time they were regularly weighed every four weeks until they were sold. The weights and other particulars are shown in Table 1.

The results as given in the table call for little comment. The daily live-weight gain from birth to the day of sale was slightly in favour of the Welsh blue-greys, but the difference between the two lots was so small that no special importance attaches to it, especially in view of the small number of animals involved. The Welsh lot had more size than the Galloway lot, and, as might have been expected from their appearance, they made a bigger average weight. They were on the average a little older than the Galloway blue-greys, but that in itself was hardly sufficient to account for the difference in size, which was unquestionably in favour of the Welsh lot. In quality, while both lots, regarded as butcher's cattle, were so good as at once to attract attention, the Galloway lot was the better of the two. Some of these, and the smallest as it happened, were almost perfect models in symmetry and form. There was a preponderance of females in the Welsh lot and of males in the Galloway lot. It is for this reason difficult and not quite fair to draw a comparison between the two sexes. Taking the results as they turned out, the bullocks had a slight advantage in daily gain over the heifers.

At the time of sale both lots commanded the highest price for butcher's cattle then obtainable, and were sold at the same price per live-weight cwt. The carcase weights were not recorded, but in regard to the quality of the beef there was, from the butcher's point of view, no appreciable difference between the Welsh and the Galloway lots. Leaving the initial cost of the dams out of account the general conclusion to be drawn from this experiment, therefore, is that Welsh blue-greys, bred under conditions such as are here described, are well worthy of the feeder's attention when compared with the Galloway cross, to which in some respects they may even be superior.

Experiment II.

The experiment now to be described was in reality a continuation of that set out above. In the summer of 1910 the Welsh Black and Galloway heifers were suckling their first calves, there being four Welsh Black and six Galloway heifers,—now perhaps to be described as cows. In July, 1910, a white pedigree Shorthorn bull, equally good but differing in breeding from that used the previous year, was turned out to the cows, which occupied now, with their calves, the

same ground as they had done the year before. The bull ran with the cows until November, and was separated from them at the same time as their calves were weaned, viz., November 9. The cows, both Welsh and Galloway, were then turned to the lower part of the farm and treated during the subsequent winter exactly as in the previous year. At the end of April, 1911, they were taken to the upper lands belonging to the farm, and here they had their second crop of calves between May and August of that year. One of the Galloway cows had returned to the bull during the winter and she was therefore eliminated from the experiment. In the second lot of calves, with which we are now concerned, there were thus five Galloway blue-greys and five Welsh blue-greys, one of the Welsh cows having this time produced twins. There was more variation in the colour of the calves on this occasion, the Welsh crosses varying most, but they were all grey of one shade or another, two of the Welsh calves having white patches on the body. There was a preponderance of females again among the calves from the Welsh cows, there being only one bull calf among them. The Galloway calves consisted of two heifers and three bulls. The calves, like those of the previous season, ran with their dams throughout the summer and autumn. The summer of 1911 was particularly dry and both cows and calves suffered in consequence. In spite of this, however, the calves were by the autumn a very attractive lot, though they were smaller at that time than were those of the year before. One of the Welsh cows, as has been shown, reared twins. Another Welsh cow had at first far more milk than was needed by her calf. In fact, these two cows would, after their second calving, have made very useful dairy cows, and in practice it would have been no doubt more profitable to have milked them rather than to have allowed them to suckle their calves, though there would not perhaps have been much difference between the two methods in the very abnormal season of 1911. This, however, is a point to be noted in comparing Welsh Black cows with Galloways for the purpose for which both were used in this experiment. None of the Galloway cows had more milk than the calf could use, and during the drought some of these calves were not getting enough.

All the calves were weaned and housed on December 14, 1911, and were fed in the same way as those of the previous year. When they had been in a fortnight they were weighed for the first time, and two or three days later the bull calves were castrated. On April 10, 1912, they were turned out to grass, where they remained until November 11, when they were housed for their second winter. They

were fed throughout the winter on a mixture of linseed cake, pea meal and crushed oats in equal parts, at an average rate of 3 lb. per head per day, together with chopped hay and pulped roots, with hay night and morning. Both lots were, of course, treated exactly alike. They occupied loose boxes with only a gangway between them as those of the year before had done. There was a plentiful supply of water in the boxes, and each lot had as nearly as possible the same amount of straw for litter. They were turned out to grass on May 3, 1913, when they were allowed 3 lb. per head per day of a mixture in equal parts of linseed cake, undecorticated cotton cake and maize meal. This was continued till the cattle were sold at the beginning of August, and Experiment II was concluded. The weights and other particulars relating to this experiment are shown in Table II.

On comparing the results it will be observed that the two lots were remarkably even, there being no difference of importance in the average live-weight and practically none at all in the daily gain. As in the first experiment, the Welsh blue-greys had this time again a slight advantage in size, though, with the exception of the Welsh blue-grey bullock (No. 5), this was not appreciably reflected in their weight. The bullock here referred to was an unusually good beast, and though generally, perhaps, the Galloway lot seemed superior to the Welsh in symmetry and thickness, this bullock, the biggest and heaviest of the whole group, was also equal to any in quality. This time again it is difficult and perhaps not quite fair to draw a comparison between the sexes, but, taking the results as they stood, the bullocks, as in Experiment I, made a slightly greater daily live-weight increase than did the heifers.

The two lots of blue-greys were sold on this occasion again at the same price per live-weight cwt. and the highest price then obtainable for cattle of prime quality for slaughter. The carcase weights were not recorded, but it is known that both lots killed well according to local standards. This is an important point in considering the relative merits of the two classes of blue-greys. The Welsh blue-greys, especially the heifers, did not in outward appearance seem to be possessed of quite the same quality, from the feeder's or butcher's standpoint, as did the Galloway blue-greys. They appeared to be somewhat more lanky and not so well-fleshed. But they apparently killed as well as the Galloway blue-greys did and in quality of carcase there was, from the meat salesman's point of view, no appreciable difference on the average between the two lots. The meat from both commanded exactly the same retail price, as was the

case also with the two lots in Experiment I. The general results of the second experiment, in this as in other respects, confirmed those of the first, and showed that under the same conditions of breeding and feeding as are applicable to the case here described, Welsh blue-greys, and especially bullocks, may well hold their own in competition with the Scotch.

General.

The experiments described in this article are no doubt open to criticism, but such as they are the conclusion to be drawn from them, on the issue for which the experiments were designed, seems to be clear enough. Apart from the general conclusion, the tables in which the results are set out furnish interesting information to the breeder and feeder. Nothing is more surprising than the extraordinary fluctuation, as shown from month to month, in the rate of progress made by cattle during their period of growth, and that often without apparent cause. Instances of this may be found in both Table I and Table II. The actual loss of weight in the cattle when turned out to grass and again when housed in the autumn is striking, but in the change of conditions there is here a definite cause to which the result may be attributed. There was no apparent cause, on the other hand, for the poor result from both lots of cattle in March, 1911 (Table I), or February, 1913 (Table II). The effect of the dry summer of 1911 is clearly shown in the August figures for that year (Table I). It is remarkable that in both experiments when the cattle had done badly, as shown in the monthly weighing, they very often more than made up for it the following month.

The average daily gain was not high in any of the lots, and was perhaps not as high as it should have been if the experiments were looked at primarily from the economic point of view. A different method of management would no doubt have resulted in a more rapid increase in weight and a quicker return. But circumstances determined very largely the method of management that was adopted. The object of the experiments was not to test a particular method of rearing and feeding against another, but to compare two differently bred lots of cattle kept under the same conditions, and that for a sufficiently long period to render the data collected reasonably reliable.

While Welsh blue-greys make excellent butcher's cattle, and are often quite equal to the popular Galloway cross, it is doubtful

whether the breeding of blue-greys from Welsh cows on the same system as the north country blue-greys are bred and reared would be found profitable. Welsh cows give far more milk than do Galloways, and after their second calving a large proportion of them are capable of doing a good deal more than rearing their own calves. Because they are better milkers, therefore, Welsh cows are on the average less suitable than Galloways for the purpose of rearing calves by suckling out on grass. Under certain conditions there is, of course, much to be said for that method, but generally speaking it is not a method for which Welsh Black cows are as well suited as are Galloways. But while this may be said as regards the system of rearing, there can be no question as to the merits as commercial cattle of the cross between Welsh Black cows and a white Shorthorn bull. The results of these experiments show that they compare very favourably as feeders with the corresponding Galloway cross. It may be added, though these experiments were not designed to test that point, that in practice many of the heifers of the Welsh cross make excellent milkers, which is rarely the case with the Galloway cross. As butcher's cattle, Welsh blue-greys are often equal to the Galloway blue-grey, and as general purpose cattle they may not infrequently be superior.

SOME STUDIES IN THE FORMATION OF PERMANENT PASTURES IN NORTH WALES.

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Experiments on the formation of pastures have been conducted by the Department of Agriculture, of the University College of North Wales, Bangor, for many years. During the years 1919—1921 a new scheme of experiments was entered upon to follow up the earlier trials. The following is the plan of the later experiments, which are alone dealt with in the present paper:—

TABLE I.

Sown 1919.

	Lb. of Seed per acre.					
	Plot A.	Plot B.	Plot C.	Plot D.	Plot E.	Plot F.
Italian Ryegrass ...	4	4	6	4	4	2
Perennial Ryegrass ...	9	—	—	9	18	18
Cocksfoot ...	5	5	7½	5	5	2½
Timothy ...	4	4	6	4	4	2
Meadow Fescue ...	2	2	3	2	2	1
Crested Dogstail ...	1	1	1½	1	1	½
Rough Stalked Meadow Grass ...	1	1	1½	1	1	½
Broad Red Clover ...	2	2	2	2	2	2
Late Flowering Red Clover ...	2	2	2	2	2	2
Alsike ...	2	2	2	2	2	2
Wild White Clover ...	—	½	½	½	½	½
Chicory ...	1	1	1	1	1	1
Yarrow ...	¼	¼	¼	¼	¼	¼
	34¼	25¾	34¾	34¾	43¾	34¾

TABLE II.

Sown 1920 and 1921.

	Lb. of Seed per acre.					
	Plot A.	Plot B.	Plot C.	Plot D.	Plot E.	Plot F.
Italian Ryegrass ...	6	—	6	6	6	6
Perennial Ryegrass ...	10	10	—	10	10	15
Cocksfoot ...	6	6	6	—	6	2
Timothy ...	3	3	3	3	3	2
Meadow Fescue ...	2	2	2	2	2	—
Crested Dogstail ...	1	1	1	1	—	½
Rough Stalked Meadow Grass ...	1	1	1	1	—	—
Broad Red Clover ...	2	2	2	2	2	2
Late Flowering Red Clover ...	2	2	2	2	2	2
Alsike ...	1	1	1	1	1	1
Wild White Clover ...	1	1	1	1	1	1
Chicory ...	1	1	1	1	1	—
Yarrow ...	¼	¼	¼	¼	—	—
	36¼	30¼	26¼	30¼	34	31½

Plots were laid down at the following centres in the respective years:—

Anglesey.

1920. Llyslew, Gaerwen, Mr. D. R. Lloyd.
1921. Glasgraig, Rhosgoch, Mr. J. R. Williams.

Carnarvonshire.

1919. College Farm (Cae Cefna Mân), Aber, U.C.N.W.
1920. College Farm (Cae Bryn Gwylan), Aber, U.C.N.W.
1920. Ysgubor Hen, Chwilog, Mr. Owen Williams.
1921. College Farm (Cae Hir), Aber, U.C.N.W.

Denbighshire.

1920. Llysfasi Farm Institute, Denbighshire Education Authority.
1921. Fachell Farm, Rhuddlan, Mr. John Edwards.

Flintshire.

1920. Wallington, Worthenbury, Mr. John Broad.
1921. Pinfold Farm, Bronington, Mr. Mottershead.
1921. Berthymaen, Trelogan, Mr. J. E. Evans.
1921. Plas-is-Llan, Cwm, Llanelidan, Mr. William McLellan.

It will be noticed that although in the main the mixtures sown in the various years are similar, the 1920 and 1921 mixtures were considerably modified from those sown in 1919. Although they were all selected with a view to securing information on certain specific points, the mixtures are essentially what one would regard as typical mixtures for a ley extending say, four years, on characteristic soils in the area. The 1919 mixtures were designed to ascertain how far the total omission of perennial ryegrass or the inclusion of this species in excessive quantities in an otherwise balanced mixture would affect the composition of the pasture when stability is arrived at. From plot to plot the amounts of the other more important grass elements have been accordingly modified to meet the fluctuations in the quantities of perennial ryegrass. It will be noticed that the Red Clover and Alsike contents are uniform throughout, while Wild White Clover is omitted from Plot A only.

The mixtures sown in 1920 and 1921 were drawn up in order to estimate how far the omission of what have up to now been regarded as cardinal species (Italian Ryegrass, Perennial Ryegrass and Cocksfoot) affects the rate of arriving at stability and the final composition of the resulting pasture. Plots E and F were likewise selected to ascertain how the omission of the smaller bottom grasses would affect the composition of the pasture.

Although these ultimate aims cannot be realised for some two or three more years, it is interesting to note how the pastures thrive in the intermediate years, and incidentally to note whether any of the grasses commonly sown have any special effect in encouraging or in retarding the development of Wild White Clover. The experiments also provided the opportunity of observing whether, under ordinary conditions, natural seeding of valuable plants could be relied on to make good any deficiencies in the seeds mixture, or to fill gaps caused by the dying out of some of the plants sown.

At all the centres except Plas-is-Llan the grass was mown for hay in the first two seasons. At Plas-is-Llan it has been mown and grazed in alternate years since the start. Details of management and cropping at the various centres both prior to and subsequent to seeding are not given here, but these have in each case been fully noted, and an endeavour made to bear them in mind when considering the summarised results. The plots in 1919 at Cae Cefna Mân, College Farm, were each one acre in size and duplicated; elsewhere they are not duplicated, and are throughout one-quarter acre plots.

Botanical Analyses of Herbage.

In all the experiments botanical analyses were made in the second harvest year, and again in the fourth year,[1] where the experiments have remained. For the second year's analyses (with the exception of Plas-is-Llan, noted above, which was grazed and sampled accordingly) samples were taken immediately before the hay harvest. Where it was possible, twenty turves were drawn per plot. As, however, the sampling of all plots at all centres so widely separated had to be undertaken within a very limited period of time, immediately before the hay harvest, this was not possible in all cases, and at one centre ten samples only, per plot, were drawn. These samples were drawn from the diagonals of each plot by driving well into the ground a circular steel collar a foot across, sharpened to a cutting edge on the underside. The turf was cut with a knife clear of the roots. The various turves drawn from each plot were dealt with collectively, each sown species being separated and all the miscellaneous unsown plants were grouped together, but were separately listed. The roots were in each case clipped off, and the groups separately bagged and air-dried until they became constant in weight —a period of generally six to eight weeks.

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1 The plots sown in 1921 do not come for the fourth year analyses until the winter of 1925. It is hoped to publish these as a supplement to the present paper at a future date.

TABLE III.

Percentage Analysis of Hay in Second Year, 1921. (By Weight).
Cae Cefna Man, College Farm, Aber. Sown 1919,
and Percentage Analysis of Grazed Pasture in December, 1924. (By Weight).

	Plot A.		Plot B.		Plot C.		Plot D.		Plot E.		Plot F.	
	(1921)	(1924)	(1921)	(1924)	(1921)	(1924)	(1921)	(1924)	(1921)	(1924)	(1921)	(1924)
Perennial Ryegrass	25.4	**13.9**	4.4	**7.3**	1.6	**8.1**	26.6	**18.5**	32.2	**24.4**	46.1	**18.5**
Italian Ryegrass	23.6	—	33.4	—	32.3	—	20.0	—	18.7	—	7.6	—
Rough Stalked Meadow Grass	2.4	**23.0**	4.3	**22.8**	3.0	**17.7**	3.7	**19.4**	4.6	**21.2**	1.9	**26.3**
Crested Dogstail	3.6	**22.8**	2.9	**13.8**	3.6	**27.2**	1.7	**24.3**	2.4	**16.8**	0.6	**22.3**
Timothy	7.0	**0.4**	14.5	**0.2**	8.0	**0.7**	6.9	**T**	7.6	**T**	6.0	**T**
Cocksfoot	1.4	**.2**	0.8	**1.8**	1.0	**0.7**	1.5	—	0.8	—	0.1	—
Meadow Fescue	0.5	—	1.4	—	3.4	**0.2**	0.2	—	trace	—	0.1	—
Red Clovers	14.3	—	11.0	—	11.1	—	14.5	—	10.8	—	14.0	—
Alsike	4.3	—	1.9	—	0.5	—	1.7	—	0.3	—	1.0	—
Wild White Clover	3.2	**17.2**	13.4	**26.5**	21.4	**18.6**	14.5	**18.8**	15.2	**16.4**	14.0	**14.4**
Chicory	0.4	**T**	0.6	—	1.0	**0.5**	0.1	—	0.1	—	0.2	—
Yarrow	0.2	**T**	0.1	**0.2**	0.1	**0.3**	0.1	—	trace	—	trace	—
Yellow Suckling Clover	8.2	**22.5**	4.7	**27.4**	3.8	**26.0**	5.5	**19.0**	3.6	**21.2**	5.1	**18.5**
Miscellaneous	5.5		6.7		4.2		3.2		3.7		3.3	
Yield in grams for total samples taken 1921	439		461		495		469		437		557	
1924	**26.1**		**17.1**		**22.1**		**22.7**		**23.7**		**24.9**	

TABLE IV.

Percentage Analysis of Hay in Second Season, 1922. (By Weight).

Sown 1920,

and Percentage Analysis of Grazed Pasture in January and February, 1925.

	PLOT A.								PLOT B.							
	*July, 1924. *College Farm.* Cae Bryngwylan.		*Feb., 1925. *Ysgubor Hen.*		*Jan., 1925. *Llyslew.*		Ploughed up. *Llysfasi.*	*Broad's Farm.*	*July, 1924. *College Farm.*		*Feb., 1925. *Ysgubor Hen.*		*Jan., 1925. *Llyslew.*		Ploughed up. *Llysfasi.*	*Broad's Farm.*
	(1922)	(1925)	(1922)	(1925)	(1922)	(1925)	(1922)	(1922)	(1922)	(1925)	(1922)	(1925)	(1922)	(1925)	(1922)	(1922)
Italian Ryegrass	5.3	—	2.9	—	10.4	—	0.3	12.0	0.9	—	—	—	—	—	—	—
Perennial Ryegrass	9.4	**3.9**	8.5	**2.7**	15.2	**4.7**	22.0	36.2	14.6	**5.3**	10.8	**3.7**	15.8	**9.1**	13.7	41.9
Cocksfoot	7.0	**22.6**	16.6	**6.6**	22.4	**0.2**	33.7	6.9	11.4	**8.4**	21.1	**5.4**	24.9	**1.7**	40.9	6.7
Meadow Fescue	0.2	**2.1**	0.4	—	0.7	—	—	1.7	2.7	**2.1**	—	—	1.9	—	—	2.0
Crested Dogstail	2.0	**6.9**	18.5	**14.0**	7.1	**1.6**	7.0	2.9	4.5	**16.4**	5.8	**3.8**	12.9	**2.9**	4.9	2.2
Timothy	8.4	**0.3**	10.8	**1.2**	0.9	—	5.9	4.0	7.3	**0.7**	11.4	**1.3**	6.2	**T**	3.5	14.0
Rough Stalked Meadow Grass	5.6	**14.9**	3.0	**16.8**	1.6	**13.5**	5.0	13.4	9.2	**21.3**	14.0	**34.3**	2.9	**13.8**	2.6	18.5
Wild White Clover	44.6	**36.4**	16.1	**20.6**	9.3	**59.3**	7.2	1.3	33.8	**33.3**	24.2	**16.0**	14.6	**45.3**	12.3	trace
Red Clovers	4.0	—	2.2	—	23.0	—	9.5	15.6	6.1	—	—	—	9.2	—	7.4	8.3
Alsike	1.3	—	0.4	—	—	—	3.3	2.0	1.3	—	3.9	—	0.2	—	3.2	—
Yarrow	1.3	**1.2**	3.4	**0.5**	—	**1.0**	—	—	.6	**0.1**	.5	**2.4**	0.9	**1.8**	—	—
Chicory	2.2	**1.2**	2.9	—	3.9	—	—	—	2.0	—	3.5	—	1.9	—	4.9	2.3
Miscellaneous	8.7	**10.5**	12.3	**37.5**	5.5	**19.7**	6.3	4.0	5.6	**12.4**	4.8	**37.1**	8.6	**25.4**	6.6	4.1
Yield in grams for total samples taken .. 1922	300		520		366		233	408	342		361		417		283	498
1924	**22.6**		**17.6**		**26.7**				**17.4**		**15.7**		**25.8**			

TABLE IV.—Continued.

	PLOT C.								PLOT D.							
	College Farm.		Ysgubor Hen.		Llyslew.		Llysfasi.	Broad's Farm.	College Farm.		Ysgubor Hen.		Llyslew.		Llysfasi.	Broad's Farm.
	(1922)	**(1925)**	(1922)	**(1925)**	(1922)	**(1925)**	(1922)	(1922)	(1922)	**(1925)**	(1922)	**(1925)**	(1922)	**(1925)**	(1922)	(1922)
Italian Ryegrass	11.1	—	5.6	—	8.1	—	5.6	21.3	11.9	**1.7**	9.4	—	8.	—	3.2	17.3
Perennial Ryegrass	1.0	—	4.1	**1.7**	4.0	**0.5**	0.7	3.6	15.3	**7.1**	17.2	**2.6**	15.5	**3.8**	37.0	39.5
Cocksfoot	8.6	**7.4**	25.9	**7.7**	20.0	**0.4**	49.0	16.5	—	—	—	**0.9**	0.6	—	—	—
Meadow Fescue	2.0	**1.0**	0.8	**0.4**	2.2	—	—	2.3	0.5	**0.2**	—	—	1.3	—	0.8	2.2
Crested Dogstail	3.8	**19.3**	7.6	**5.2**	11.6	**2.4**	15.4	5.0	3.0	**6.2**	21.0	**3.0**	16.5	**4.0**	10.5	1.5
Timothy	5.2	**0.4**	7.2	**1.2**	6.4	—	2.6	8.4	4.8	**13.3**	3.8	**0.9**	3.3	**0.2**	5.5	7.8
Rough Stalked Meadow Grass	15.9	**21.4**	7.2	**39.8**	4.3	**17.8**	2.3	19.8	11.7	**15.9**	17.3	**34.7**	5.3	**20.4**	5.1	10.3
Wild White Clover	36.4	**36.9**	16.0	**16.0**	10.5	**43.3**	6.2	1.4	33.5	**26.9**	14.0	**15.2**	19.1	**43.0**	10.9	1.9
Red Clovers	0.2	—	6.1	—	11.1	—	6.2	8.0	5.9	—	2.0	—	14.2	—	7.8	6.6
Alsike	—	—	1.0	—	1.3	—	1.4	3.4	4.0	—	—	—	1.2	—	4.4	—
Yarrow	0.3	**1.2**	2.6	**1.1**	1.3	**0.8**	0.3	—	0.9	**0.6**	2.9	**T**	T	**2.0**	—	—
Chicory	2.5	**0.4**	3.9	—	8.0	—	1.3	1.6	2.8	—	2.6		6.4	—	0.4	—
Miscellaneous	13.0	**12.0**	12.0	**26.9**	11.2	**34.8**	9.0	8.7	5.7	**28.1**	8.8	**42.7**	6.1	**26.6**	14.4	12.9
Yield in grams for total samples taken .. 1922	**314**		390		378		267	444	307		287		396		252	401
1924	**15.9**		**18.1**		**33.1**				**20.3**		**16.6**		**25.5**			

TABLE IV.—Continued.

	PLOT E								PLOT F.							
	College Farm.		*Ysgubor Hen.*		*Llyslew.*		*Llysfasi.*	*Broad's Farm.*	*College Farm.*		*Ysgubor Hen.*		*Llyslew.*		*Llysfasi.*	*Broad's Farm.*
	(1922)	**(1925)**	(1922)	**(1925)**	(1922)	**(1925)**	(1922)	(1922)	(1922)	**(1925)**	(1922)	**(1925)**	(1922)	**(1925)**	(1922)	(1922)
Italian Ryegrass	4.0	—	10.9	—	13.6	—	trace	5.5	6.1	**1.4**	8.3	—	10.3	—	1.2	8.6
Perennial Ryegrass	13.9	**12.8**	11.5	**2.0**	11.3	**4.5**	24.8	27.3	16.0	**12.3**	11.4	**1.9**	15.5	**4.3**	26.0	55 1
Cocksfoot	6.8	**8.0**	26.5	**3.5**	18.4	**0.6**	42.0	11.9	2.3	**2.7**	22.7	**0.7**	8.7	**0.1**	25.4	2 9
Meadow Fescue...........	—	**2.1**	trace	—	—	—	0.5	0.6	—	—	—	—	—	—	—	—
Crested Dogstail	—	**0.2**	—	**3.1**	—	**1.9**	—	—	2.3	**11.0**	9.4	**6.3**	8.2	**7.9**	7.2	2.2
Timothy	2.6	**4.0**	10.9	**0.2**	7.1	**0.2**	8.0	16.5	10.0	**1.0**	14.2	—	4.7	—	2.5	3.7
Rough Stalked Meadow Grass	9.8	**16.5**	2.6	**41.9**	2.0	**32.5**	1.4	20.1	15.8	**22.6**	5.0	**43.9**	1.6	**19.1**	1.2	9.5
Wild White Clover	46.9	**26.3**	13.2	**13.4**	17.2	**29.6**	3.9	2.0	33.0	**42.3**	16.2	**13.2**	12.0	**32.1**	10.8	0.9
Red Clovers	3.7	**1.3**	0.9	—	6.6	—	15.3	9.9	7.0	—	0.5	—	17.8	—	9.4	12.7
Alsike	0.2	—	0.1	—	0.8	—	0.7	—	—	—	—	—	1.9	—	0.2	trace
Yarrow	—	—	—	—	—	**1.0**	—	—	—	—	—	**3.0**	—	**1.5**	—	—
Chicory	3.0	—	6.6	—	7.0	—	0.9	—	—	—	—	—	—	—	—	trace
Miscellaneous	9.1	**28.8**	16.8	**35.9**	17.0	**29.7**	2.3	6.2	7.5	**6.6**	12.3	**31.0**	19.3	**35.0**	6.1	4.6
Yield in grams for total samples taken .. 1922	275		346		354		273	395	262		384		336		282	443
1924	**16.9**		**13.6**		**21.4**				**19.7**		**14.2**		**19.0**			

TABLE V.

Percentage Analysis of Hay in Second Season, 1923. (By Weight).

Sown 1921.

	PLOT A.						*PLOT B.*					
	Pinfold Farm. F.	*Fachell Farm.* D.	*Glasgraig.* A.	*Berth-y-Maen.* F.	*College Farm.* C.	(Grazed) Plas-is-Llan. F.	*Pinfold Farm.*	*Fachell Farm.*	*Glasgraig.*	*Berth-y-Maen.*	*College Farm.*	(Grazed) Plas-is-Llan.
Italian Ryegrass	4 2	1.4	3.2	8.3	2.8	**3.0**	0.5	0.9	abs.	abs	0.1	**0.4**
Perennial Ryegrass	35.1	21.5	20.8	32.4	28.8	**26.1**	40.3	12.6	11.7	23.1	47.3	**29.3**
Cocksfoot	26.3	22.8	22.3	12.5	10.4	**3.4**	20.1	20.9	32.9	18.5	15.6	**6.8**
Timothy	2.4	0.2	7.4	3.2	8.5	**0.5**	0.8	1.4	7.9	1.6	16.3	**abs.**
Crested Dogstail	3.4	abs.	0.5	1.0	2.7	**3.0**	0.2	0.2	2.4	0.1	0.6	**5.3**
Meadow Fescue..........	0.2	0.4	0.4	0.7	1.7	**abs.**	0.5	abs.	0.4	1.3	5.0	**abs.**
R.S. Meadow Grass	7.2	6.2	6.3	7.4	6.0	**29.7**	5.3	5.0	9.1	10.0	2.0	**24.7**
Wild White Clover	9.0	6.2	10.3	12.0	12.1	**23.8**	10.8	12.0	5.2	17.3	10.6	**22.1**
Red Clovers	6.5	31.8	18.9	18.2	18.9	**0.3**	7.3	25.1	21.2	19.8	17.8	**4.1**
Alsike Clover	0.1	2.9	3.2	2.1	4.1	**abs.**	0.5	10.8	3.2	4.5	1.2	**abs.**
Yarrow	0.5	abs.	abs.	0.1	abs.	**0.5**	abs.	0.2	0.2	0.2	0.2	**0.4**
Chicory	2.1	0.4	0.9	1.3	0.6	**0.2**	9.8	0.5	0.1	0.2	0.9	**abs.**
Miscellaneous	1.0	6.2	5.8	0.8	3.4	**9.5**	3.9	10.4	5.7	3.4	2.4	**6.9**
	530.2	451.4	393.5	619.4	411.3	**50.72**	387.4	397.2	412.8	622.3	458.7	**55.08**

TABLE V.—Continued.

Percentage Analysis of Hay in Second Year, 1923. (By Weight).

Sown 1921.

	PLOT C.						PLOT D.					
	Pinfold Farm.	*Fachell Farm.*	*Glasgraig.*	*Berth-y-Maen.*	*College Farm.*	**(Grazed) Plas-is-Llan.**	*Pinfold Farm.*	*Fachell Farm.*	*Glasgraig.*	*Berth-y-Maen.*	*College Farm.*	**(Grazed) Plas-is-Llan.**
Italian Ryegrass	10.7	1.6	14.0	16.9	7.2	**2.4**	9.9	abs.	4.7	14.7	1.8	**21.4**
Perennial Ryegrass	11.3	1.2	0.9	4.5	14.4	**16.5**	43.3	12.9	22.1	24.4	37.8	**7.8**
Cocksfoot	31.3	27.7	6.8	20.6	7.9	**2.8**	0.2	abs.	abs.	abs.	abs.	**1.8**
Timothy	2.1	1.8	15.6	6.1	13.6	**0.8**	0.8	0.8	13.2	2.9	4.5	**2.3**
Crested Dogstail	1.5	1.3	1.8	2.7	2.1	**3.3**	5.6	abs.	6.8	1.7	2.7	**2.5**
Meadow Fescue	0.4	5.5	1.3	1.3	4.2	**abs.**	0.3	abs.	0.2	0.1	2.0	**abs.**
R.S. Meadow Grass	7.7	3.8	11.4	11.5	5.1	**9.8**	5.1	4.3	7.4	5.7	2.1	**6.4**
Wild White Clover	8.8	4.8	11.5	19.1	22.9	**22.9**	12.8	6.0	10.5	15.1	16.7	**28.7**
Red Clovers	11.8	43.5	7.4	3.3	11.6	**23.6**	12.5	65.4	28.4	25.6	22.8	**2.3**
Alsike Clover	2.5	1.2	3.5	4.3	1.6	**3.3**	0.9	1.4	3.0	0.2	4.4	**abs.**
Yarrow	abs.	abs.	0.4	0.7	abs.	**0.5**	0.2	abs.	0.2	0.1	0.5	**0.6**
Chicory	1.4	3.0	0.6	2.2	2.9	**abs.**	0.6	0.2	0.1	1.7	0.8	**abs.**
Miscellaneous	10.6	4.6	4.8	6.8	6.5	**14.1**	7.8	9.0	3.4	7.8	3.9	**26.2**
Yield in grams for total samples taken	497.4	439.7	445.4	500.8	531.2	**61.04**	399.8	489.0	430.3	536.0	433.1	**44.88**

TABLE V.—Continued.

Percentage Analysis of Hay in Second Season, 1923. (By Weight).

Sown 1921.

	PLOT E.						*PLOT F.*					
	Pinfold Farm.	*Fachell Farm.*	*Glasgraig.*	*Berth-y-Maen.*	*College Farm.*	**(Grazed) Plas-is-Llan.**	*Pinfold Farm.*	*Fachell Farm.*	*Glasgraig.*	*Berth-y-Maen.*	*College Farm.*	**Graz Plas-is-Llan.**
Italian Ryegrass	10.4	2.1	6.9	17.6	4.0	**1.7**	15.0	0.2	11.6	11.8	7.7	**9.0**
Perennial Ryegrass	38.5	15.5	16.6	13.7	21.2	**14.7**	40.6	10.8	22.8	26.8	29.6	**18.2**
Cocksfoot	15.2	6.8	33.0	12.5	19.2	**2.5**	10.7	0.8	18.6	11.8	9.2	**3.7**
Timothy	4.0	0.2	16.1	0.9	5.6	**abs.**	0.2	abs.	6.3	abs.	6.2	**3.0**
Crested Dogstail	abs.	abs.	0.1	abs.	abs.	**22.5**	0.9	abs.	7.2	0.5	4.9	**abs.**
Meadow Fescue..........	0.2	abs.	0.8	abs.	0.9	**abs.**	abs.	abs.	abs.	abs.	0.3	**abs.**
R.S. Meadow Grass	4.1	3.7	0.2	3.6	1.9	**3.6**	1.7	5.9	0.4	3.2	1.6	**1.2**
Wild White Clover	14.0	3.3	6.3	8.7	12.7	**24.3**	12.6	3.7	12.3	11.5	13.2	**49.2**
Red Clovers	7.8	60.9	16.9	23.9	25.2	**abs.**	16.2	57.5	15.1	26.7	17.9	**0.4**
Alsike Clover	1.5	0.4	1.7	2.9	3.3	**abs.**	1.5	4.1	0.7	3.9	5.2	**abs.**
Yarrow	abs.	abs.	abs.	abs.	abs.	**0.3**	abs.	abs.	abs.	abs.	abs.	**0.5**
Chicory	1.0	0.2	0.4	6.4	1.1	**abs.**	abs.	abs.	abs.	abs.	abs.	**abs.**
Miscellaneous	3.3	6.9	1.0	9.8	4.9	**30.4**	0.6	17.0	5.0	3.8	4.2	**14.8**
	430.8	395.4	495.9	493.8	486.4	**68.25**	448.5	391.4	439 8	500.7	486.4	**51.80**

TABLE V (a).

Analysis of Grazed Pasture in Second Year, 1923. Sown 1921. (By Weight).
Plas-is-Llan, Cwm, Llanelidan, Denbighshire.

	A.	B.	C.	D.	E.	F.
Italian Ryegrass	3.0	0.4	2.4	21.4	1.7	9.0
Perennial Ryegrass	26.1	29.3	16.5	7.8	14.7	18.2
Cocksfoot	3.4	6.8	2.8	1.8	2.5	3.7
Timothy	0.5	trace	0.8	2.3	trace	3.0
Crested Dogstail	3.0	5.3	3.3	2.5	22.5	abs.
Meadow Fescue			Absent	Through	out.	
R.S. Meadow Grass	29.7	24.7	9.8	6.4	3.6	1.2
Wild White Clover	23.8	22.1	22.9	28.7	24.3	49.2
Red Clovers	0.3	4.1	23.6	2.3	trace	0.4
Alsike Clover	trace	trace	3.3	trace	trace	trace
Yarrow	0.5	0.4	0.5	0.6	0.3	0.5
Chicory	0.2	0.2	0.3	0.3	0.2	abs.
Miscellaneous	9.5	6.7	13.8	25.9	30.2	14.8
Yield in grams for total samples taken	50.72	55.08	61.04	44.88	68.25	51.80

The representation of each group or species is then given as a percentage of the total air-dried weight of all the ingredients of the herbage.

For the fourth year's analyses samples were drawn in the winter period (November—March), twenty samples per plot being drawn with a frame twelve inches by one inch and the ingredients dealt with as given above for the second year's herbage. It will be noted that for all the centres the final representation of the herbage of any species or group is in the form of a percentage by weight of the whole air-dried produce, from which the roots have been removed.

A.—Consideration of Results of Examination in Second Year's Hay Crop.

Plots sown in 1919. *Examined in* 1921.

1. The yield of hay, where Perennial Ryegrass is totally omitted, shows no appreciable diminution. The loss seems, on the whole, compensated for in a corresponding increase in the productivity of Italian Ryegrass and Wild White Clover.

2. An apparently excessive seeding of Perennial Ryegrass as shown in Plots E and F gives an increased yield of grass proportionate to the rate at which it was augmented. This does not appear to prove detrimental to the other ingredients.

3. Where Perennial Ryegrass is not included in the mixture there is no appreciable quantity established through other means, such as the growth of the indigenous form.

4. The bulk of Cocksfoot, Alsike Clover, Chicory and Yarrow is not enough to warrant their inclusion in a balanced mixture as far

as bulk of hay in the second harvest year obtains. They may, however, thrive appreciably when the pasture enters on its next phase with the decline of the members that occupy the ground only for brief periods during the early life of the ley.

5. The excess of Wild White Clover on the plots where it was sown over that on the plot where it was not included indicates that it is worthy of inclusion in seeds mixtures for comparatively short leys. Though it may not figure largely in a hay crop cut with the mowing machine, its usefulness for pasture purposes is obvious.

Plots sown in 1920. *Examined in* 1922.

The drought of 1921, and of the early summer months of 1922, badly affected the yields on most of the plots. This was particularly noticeable at Llysfasi and on the College Farm, where the land had been grazed late with sheep and had consequently no covering when the drought set in in May of 1922. At the College Farm, however, an excellent cover of Wild White Clover was established, and this reduced the loss to a great extent. The best ley was undoubtedly that at Llyslew. That at Ysgubor Hen was good in parts, but badly parched in others where gravel pockets occurred in the ground. The best yield was got at Broad's Farm. This was, however, exclusively top growth of the coarser plants. It had very little, if any, of the finer bottom plants. The absence of these will probably result in difficulty in establishing a close permanent turf in the next few years.

1. Where not included in the sown mixture there is no appreciable quantity of either Italian or Perennial Ryegrass produced naturally.

2. Though the conditions were too severe for any natural Cocksfoot to establish itself, that sown undoubtedly survived, and even actually won ground where the severe drought set other species back.

3. Crested Dogstail under drought conditions warrants its inclusion in appreciable quantities for the intermediate period in a ley.

4. Meadow Fescue makes no contribution to the hay during the intermediate years. Its distribution is so scanty that it is doubtful whether the few survivors will serve as useful nuclei of colonisation in the next phase of the pasture. This fact is the more significant since the indigenous plant thrived in the hedgerows at several of the centres.

5. Rough Stalked Medow Grass, on the ground that is suited to it, is naturally established where not sown. Elsewhere its bulk does

not seem to warrant its inclusion on the score of the intermediate and early life of the ley.

6. The actual representation of the Red Clovers is much smaller than what one would be led to believe by casual observation. The contribution of Alsike Clover under drought conditions is very small indeed.

Plots sown in 1921 *and examined in* 1923.

The plots at Plas-is-Llan cannot well be compared with the rest of the centres, as this centre was grazed in its second season, while elsewhere a hay crop was taken.

I. Occurrence of Species omitted from the mixture.

Where they were not sown there is found of Italian Ryegrass or of Cocksfoot no more than one would expect to have been established from seeds shed in carting over the plots. There are but traces of Perennial Ryegrass where unsown at three of the centres, but on the heavier ground from 11 per cent. to 16 per cent. occurs. Likewise we find but traces of Crested Dogstail where not sown, with the exception of the anomalous centre Plas-is-Llan. Here there was in the second year 22 per cent. of this grass in the grazed plot. This was ratified by a re-examination on the ground, and an error in sampling, which was thought a possible explanation, was ruled out. The plots are laid on well-defined ridges.

Rough Stalked Meadow Grass, where not sown, appears in a quantity ranging from 2 per cent. to 6 per cent., but no traces of Meadow Fescue were seen, and with the exception of Plas-is-Llan, where the land was grazed in the second year, we get no Yarrow under these circumstances.

II. Effect of omission of species on the development of Wild White Clover.

FACHELL: The quantity of Wild White Clover appreciated from what it was in the full mixture on Plot B only, where Italian Ryegrass was omitted. As Italian Ryegrass had perished out of all the other plots also by the second year, if the appreciation of Wild White Clover has any significance at all, it must be regarded as an index of the advance made by this plant during the first year of the life of the ley.

GLASGRAIG: Wild White Clover appreciated very slightly on Plots C and F, but depreciated considerably on Plots B and E.

BERTHYMAEN: There is considerable increase over the plot where the full mixture was sown on Plots B, C and D. A decrease is found on Plot E, while on Plot F it stands unchanged.

COLLEGE FARM: The quantity appreciated very considerably on Plots C and D, where Perennial Ryegrass and Cocksfoot respectively were omitted from the mixture. There was no change on Plots E and F, and on Plot B the quantity depreciated.

PINFOLD FARM: With the exception of Plot C, Wild White Clover appreciated a little on all the plots, but more so on Plots D, E and F, where the omissions affect bottom growth. The proportion of Wild White Clover was high throughout the plots at this centre. The above facts are more significant inasmuch as the bottom grasses generally had not taken well at the centre.

PLAS-IS-LLAN: There was little change here from the plot with the full mixture, with the exception of Plot F, on which the quantity of Wild White Clover was doubled. An effect equivalent to this which could reasonably have been expected on Plot E was probably negatived because the clover had to compete with the spurious Crested Dogstail which, though unsown in this plot, was present to the extent of 22 per cent.

III. Effect of omission of species on the strength of miscellaneous unsown plants.

FACHELL: The weed flora appreciated considerably on Plots B and D, and it almost trebled its bulk on Plot F. Here couch grass came in considerably (in part at least from an adjacent plot not in the experiment). There was slight depreciation of the miscellaneous elements on Plots C and E.

GLASGRAIG: There was very little change throughout in the percentage of weed flora at this centre; nowhere, within the plots, did the percentage of miscellaneous plants exceed 6 per cent.

BERTHYMAEN: In the complete mixture sown on Plot A there was less than 1 per cent. of weeds. It appreciates on all the other plots, being 8 per cent. and 10 per cent. on F and E respectively. Where Perennial Ryegrass and the bottom grasses respectively were omitted, Bent Grass showed up in considerable quantity.

COLLEGE FARM: Here also the bulk of miscellaneous plants was low throughout. There was little variation from plot to plot, but as at Berthymaen, it was highest where Perennial Ryegrass and the bottom grasses were omitted. The quantity was doubled on the former plot—C.

PINFOLD FARM: The weed flora was much augmented at this centre also by the omission of Perennial Ryegrass, Cocksfoot and the bottom grasses.

PLAS-IS-LLAN: With the exception of Plot B the miscellaneous flora appreciated throughout. There was a high proportion throughout. Where Cocksfoot was omitted it formed a quarter of the total bulk yield, and in Plot E, with the omission of the bottom elements, close on a third of the total herbage was of a miscellaneous character.

IV. Hay yield of the plots.

In the case of Llyslew, Mr. Griffith Jones, B.Sc., Director of Agriculture for Anglesey, determined the weight of hay on the various plots in their first harvest year. The crop from an aliquot portion of each plot was weighed as soon as it was cut and in the green condition, but dry. The harvested crop was reckoned as a third of the weight in the green state, and these weights give a fair estimate of the relative bulk yields of the plots. Likewise Mr. Isaac Jones, B.Sc., Principal of the Llysfasi Farm Institute, determined the weight of hay on the various plots at Fachell Farm, Rhuddlan, in 1924, and at Llysfasi for the years, 1921, 1922 and 1923. The plots at the College Farm (Cae Hir) sown in 1921 were also weighed in 1923. The weights of the above mentioned are given here.

TABLE VI.

Yield of Hay per acre.

Plot.	Llyslew, 1922	Fachell, 1924	Llysfasi, 1921	Llysfasi, 1922	Llysfasi, 1923	College Farm,[2] 1923
	t. c. lb.	t. c. lb.	t. c. lb.	t. c. lb.	t. c. lb.	t. c. lb.
A	2 13 64	2 17 16	0 13 0	1 2 72	1 16 16	1 13 0
B	2 15 40	3 2 56	0 14 20	1 6 76	0 14 40	1 16 0
C	2 14 52	3 15 0	0 10 8	1 4 10	2 2 64	2 0 0
D	2 18 4	2 17 16	0 18 56	1 4 0	1 19 0	1 10 0
E	2 11 88	2 14 40	0 19 44	1 11 20	2 3 56	1 17 0
F	2 9 12	3 0 80	1 4 28	1 2 0	1 18 84	1 15 84

Mr. Isaac Jones, in comment on the 1924 yield at Fachell, remarks that as the season was so wet the figures should not be regarded as true indications of the value of the various mixtures, but that they merely afford a basis of comparison of the relative merits of the plots for hay for that particular year.

2 Weights given to the nearest quarter.

The yields at Llysfasi, particularly as regards 1921, and to some degree for the subsequent years, need some explanation. The plots were grazed with sheep late into the spring of 1921 on the maiden seeds. As soon as the plots were put up for hay, and before a cover was formed, a severe drought set in and the plots suffered badly. The series was ploughed up in the winter of 1923-24.

It is interesting to test if the bulk yield of samples drawn for botanical analyses from a plot has any significance as an index of yield when tested against the method of yield determination as shown by weighing the whole, or at least a big fraction, of the plots in the yard or in the field. One naturally expects the error to be considerable where such a small fraction as these samples is taken to represent bulk yield of the crop. However, the comparatively close agreement between the two estimates, as shown below, indicates that the weight of the hay samples drawn in the field by the steel collar is, at least, of some use as an index of relative bulk yields of plots.

TABLE VII.

Relative order of plots at various centres as shown by small samples compared with relative order as shown by actual weight of whole or major fractions of plots.

	Llyslew, 1922.	Llysfasi, 1922.	College Farm, 1923.
Plots in order of hay yield in bulk ...	D, B, C, A, E, F.	F, E, B, C, D, A.	C, E, B, F, A, D.
Plots in order of yield of small samples ...	B, D, C, A, E, F.	F, B, E, C, D, A.	E, C, F, B, D, A.

It is felt, however, that, as the hay crops in the first two years were weighed at but a few centres, the number is too small to allow of any general conclusions being drawn from them.

B. Re-examination in 1924-25 of Plots sown in 1919 and 1920.

The plots sown in 1919 and 1920 were again examined from July, 1924, onward. The only centre examined in the summer condition was Cae Bryn Gwylan on the College Farm, sown in 1920. Cae Cefna Mân, College Farm, sown in 1919, Llyslew and Ysgubor Hen, sown in 1920, were examined in the winter condition from Christmas, 1924, till March, 1925. The plots at Llysfasi had been ploughed up in the early part of 1924, and those at Wallington, Worthenbury, were so badly damaged by colts running out over them in the winter that representative samples could not be drawn from the sodden ground in February, 1925. All the above centres were grazed at the time

of sampling. The sequence of wet seasons recently experienced, particularly in 1923 and 1924, has caused degeneration in pastures generally, while in the case of the sown pastures under review in certain instances it has been exceptionally pronounced and rapid. This is particularly obvious at Cae Cefno Mân on the College Farm, laid down in 1919, and as this was laid down in accordance with a scheme different from the rest it will be dealt with first.

I. Cae Cefna Mân, College Farm. Sown 1919. *Re-examined* 1924-25.

Notwithstanding the somewhat comprehensive range of ingredients introduced here, and maintained throughout the whole range of plots, many of the species generally regarded as permanent elements of a pasture have passed away by 1924. They were represented by but faint traces, if at all.

Italian Ryegrass is, of course, a flying element doing service for the first two years only; but it is discouraging to find that Timothy, Cocksfoot, Meadow Fescue, Red and Alsike Clovers, together with Yarrow and Chicory, are completely dissipated in five years.

In all the plots we find that with the exception of Perennial Ryegrass, which was the true variable ingredient from plot to plot (other ingredients, it will be recalled, were raised to compensate for increase or decrease of Perennial Ryegrass as the case might be), there has been a process of smoothing down, so that, speaking broadly, all the plots alike have a good and even representation of Rough Stalked Meadow Grass, Crested Dogstail, Wild White Clover and miscellaneous plants.

In Plots B and C, where no Perennial Ryegrass was sown, we find that by 1924 this plant is present to the extent of 7 per cent. and 8 per cent. respectively. On Plot A, which was the standard plot, with the omission of Wild White Clover, we find 14 per cent. of Perennial Ryegrass; whereas on Plot D, including Wild White Clover in the standard mixture, the percentage rises above 18. On Plot E, where the seeding of this plant was double what it was elsewhere in the standard mixture its percentage is the highest of all found, viz., 24. On Plot F, with a double seeding of Perennial Ryegress, where the seeding of other species was reduced accordingly, it is identical with what is on Plot D, viz., 18 per cent.

II. College Farm, Llyslew and Ysgubor Hen. Sown in 1920. *Re-examined in* 1924-25.

Cae Bryn Gwylan, of the College Farm, was finally examined in August of 1924, and therefore cannot be strictly compared with the

plots at Llyslew and Ysgubor Hen, examined in the winter condition, between New Year and Lady Day of 1925. As was previously mentioned in the case of Cae Cefna Mân at the College Farm, a process of weeding out the species has operated here also. We arrive at a stage where, along with roughly a 20-25 per cent. fraction of miscellaneous plants, we get Perennial Ryegrass, Rough Stalked Meadow Grass, Crested Dogstail, Cocksfoot and Wild White Clover alone of the sown species well represented.

Perennial Ryegrass is highest throughout at the College Farm and lowest at Ysgubor Hen, and is intermediate throughout at Llyslew. The reverse is the case with respect to the miscellaneous weed flora. It is highest at Ysgubor Hen and lowest at the College Farm. These observations bear out the fact that the land at the former centre is not in such good heart and is much lighter in character than is the case at the latter centre.

Cocksfoot is throughout very low at Llyslew (on Plot D alone does it exceed 1 per cent.). At the other two centres it is well represented, ranging at the College Farm from a maximum of 22 per cent. on Plot A to a minimum of 3 per cent. on F, with an even 7-8 per cent. on all other plots where sown. At Ysgubor Hen there is an even 4-7 per cent. of it, and where not sown 1 per cent shows in the pasture after four or five years, though none was sampled from this plot at two years old. This grass is not favoured on cattle-grazing farms in the area, of which Llyslew is a type. It is, however, much appreciated by sheep graziers, which the other two centres represent. From the above figures it seems that in each case either the desired end (at Llyslew the suppression of Cocksfoot and at Ysgubor Hen and the College Farm the fostering of Cocksfoot) is reached by directed and judicious management in the intermediate years, or else one must say that cattle grazing is prejudicial to Cocksfoot while sheep grazing favours it.

In the complete mixture Crested Dogstail does not figure much except on the lighter land at Ysgubor Hen, with 14 per cent. On the College Farm alone has it appreciated by the omission of Perennial Ryegrass. At no centre does the omission of Cocksfoot appear to have benefited this plant. A little of it has appeared where not sown, with its maximum of 3 per cent. at Ysgubor Hen. Where only half the quantity was sown, but where Rough Stalked Meadow Grass also was omitted it has at all centres thriven to the extent of between 6 and 11 per cent. This leads one to think that at least one factor deciding the distribution and bulk of Crested Dogstail is the presence or absence of other virile bottom grasses such as the one mentioned.

This statement is only possible on the ground that Crested Dogstail must have established itself in bulk in years prior to this, for by 1925 we find a bulk representation of Rough Stalked Meadow Grass on plots where not sown ranging between 13 and 42 per cent. This is undoubtedly an indigenous strain, of a very aggressive nature, for it was only present in minor qualities at the time of the earlier analyses at all centres. When sown in the plots, Rough Stalked Meadow Grass maintains an even and high percentage distribution throughout—from 16-20 per cent. on the College Farm, from 13-32 per cent. at Llyslew, and from 17-42 per cent. on the lighter soil at Ysgubor Hen.

Turning to Wild White Clover, it is a significant fact that with the exception of the College Farm, where the omission of Crested Dogstail, Rough Stalked Meadow Grass and Yarrow, all bottom plants on Plot F, has increased the representation of Wild White Clover by 6 per cent., on none of the other plots at any of the centres have omissions of species benefitted the distribution of Wild White Clover. At Llyslew and at Ysgubor Hen, Plot A has by far the highest percentage of Wild White Clover. It is gratifying to find that this desirable pasture element, which does not show up well in winter, figured in the winter analyses of all plots between 29 per cent. and 59 per cent. at Llyslew, and between 13 per cent. and 20 per cent. at Ysgubor Hen. At the College Farm from a summer analysis it ranges from 26 per cent. to 42 per cent.

Traces, and traces only, remained of Meadow Fescue, Red Clovers, Alsike Clover and Chicory by the fourth year. By this time Timothy and Yarrow also can only be regarded as very minor and incidental ingredients of the pastures.

C. Preliminary Conclusions.

It is too early yet to draw any definite conclusions from the experiments, as, at the majority of the centres, only one botanical analysis has, up to now, been made. At the three centres laid down in 1920, and here reported upon, still further changes will doubtless be manifest at the time of the next analysis some time hence. The following observations are, however, suggested by the results obtained up to date:—

1. There is no unanimity in the findings of the experiments that can be traced over all the centres. The differences between the general results at the various centres are far greater than the difference between the herbage produced by the various seed mixtures.

tested. It is obvious that the soil factor and management factor from centre to centre outweigh for the first few years, at least (and these alone are the years covered by the data in hand), the influence of any ordinary internal modification within the seeds mixtures as from plot to plot. It follows, then, that it is more profitable to compare the various plots within the several centres, separately and singly, than to compare and contrast the centres the one against the other.

2. Probably the most important character of the soil, judged from its effects on the composition of the ultimate permanent herbage, is its wetness or dryness. From data gathered as to the manuring of these centres, the available phosphate is undoubtedly the most important and occupies maybe a key position in this aspect of the question. As regards other treatment, it appears that regulation of grazing is the vital factor. Many of the so-called permanent elements will not survive long in our climate if grazed almost continuously by sheep, as is often necessary under North Wales conditions.[3]

3. The only obviously clear case of a permanent effect on the final herbage produced by modification of the seeds mixture is that produced by the inclusion or ommission of Wild White Clover from the seeds mixture. Other internal modifications of the seeds mixture may have an effect on the herbage of the first two years, particularly where hay is taken, but after that, and particularly under close grazing, the character of the herbage may show very little direct relation to the seeds sown. The effect of including Wild White Clover in the seeds mixtures has, however, been very marked even seven years after sowing.

4. Of the species usually sown in a mixture, only Wild White Clover and Rough Stalked Meadow Grass have more than held their own, even up to the fourth year. Crested Dogstail, though apparently ready to take possession of unoccupied ground, has not proved at all aggressive. Timothy (even in the second year's hay crop) has proved rather disappointing, and represented almost a negligible proportion of the fourth year's pasture. Cocksfoot, though constituting an important part of the second year's hay, appears to fade out under close grazing. Perennial Ryegrass, whether sown in large quantities or only in moderate amounts, has, so far, failed to gain any

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[3] In experiments more recently laid down, attention is paid to strains of various species of pasture grasses, with the purpose of testing the relative merits of grazing and mowing forms of Cocksfoot, Perennial Ryegrass, Timothy and Meadow Fescue of various origins.

prominence, and even at the end of the fourth year was practically absent on the plot where it was not sown.

5. There was a very marked increase in the representation of weeds and miscellaneous plants on all plots by the foruth winter. This deterioration is doubtlessly due in part to the sequence of wet summers and autumns from 1922-24. There is little doubt, however, that this increase is very real, and represents a deterioration so marked that in some instances the more profitable and reasonable course would be to plough the grass up.

6. It would seem that there is much to commend such grasses as Crested Dogstail and Rough Stalked Meadow Grass. Elsewhere they may perhaps with justice be regarded as second rate pasture plants, but in our climate and under our conditions, if only on the score of persistency, it is better to include a virile form of such plants than a plant of a superior species that fails to maintain itself.

It would seem, therefore, that, assuming a mixture of grass seeds provides for the production of good hay crops in the first two years and contains, besides, an adequate proportion of Wild White Clover seed, there is no warrant for extending it beyond to the dimensions of the old type of comprehensive mixture. Comparatively, simple mixtures, properly selected are not only cheaper, but likely to give better results. The simpler the mixture, however, the more necessary is it to be careful in the selection of its ingredients, and to sow not only good seed of the right species, but also, as far as possible, to secure the most suitable strain of those species. The mixture A, with the possible omission of Meadow Fescue, Chicory, Yarrow and Alsike may be taken as a fairly safe guide for average North Wales conditions. Whether it gives satisfactory results beyond three or four years will depend largely on the character of the soil and the treatment which it receives.

In all cases Wild White Clover should be sown if only from the point of view of checking the growth of undesirable weeds and maintaining the fertility of the soil.

It is evident that on many types of soil, even in a wet climate, it is difficult to maintain grass in a satisfactory condition for more than about three years and the rotation should accordingly be shortened. In all cases the first three or four years are usually much the more productive, and it is better to err on the side of ploughing up rather early than of leaving the pasture to become full of bent grass and other undesirable weeds.

THE QUANTITATIVE AND QUALITATIVE RESPONSE OF COCKSFOOT (*DACTYLIS GLOMERATA LIN.*) TO SODIUM NITRATE AND TO SUPERPHOSPHATE.

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The trials briefly discussed in the present paper were undertaken during 1924 on pure cultures of Cocksfoot, the chief aim being to ascertain whether different pedigree strains reacted differentially to nitrogenous and phosphatic fertilizers respectively. It is proposed here to deal primarily with the response given by the strains as a whole—mention only being made incidentally to the individual strains as such.

Material and Methods.

Two methods of experimentation were adopted. The one plan was to set out the pedigree strains in " tiller beds " in a manner previously described.[1] The other plan was to set out large spaced propagants of the strains under test, each plant being broken into twenty-five equal portions—two propagants forming the unit respectively for the control (unmanured), the sodium nitrate and superphosphate,—separate units being subjected to hay and " pasture " cutting. Both the beds and propagants were set out in the late Autumn of 1922 and were thus thoroughly established by April 28th, 1924, when the dressings were applied. The sodium nitrate was given at a rate equivalent to 2 cwt. per acre and the superphosphate equivalent to 4 cwt. per acre. Three separate trials were undertaken, namely:—B.139 I, which consisted of five pedigree strains (four indigenous and one exotic), set out in duplicate " tiller beds "; B.56 VI, which consisted of thirteen pedigree strains (all indigenous), set out in quadruplicated " tiller beds "; and B.56 VII, which consisted of twenty-one pedigree plants (all indigenous), set out as spaced propagants. Stem and leaf[2] and other botanical analyses were made on the product harvested from the plots variously treated. In addition chemical analyses were conducted on the pasture produce taken from B.56 VII.[3]

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1 Stapledon, R. G. " Seasonal Productivity of Herbage Grasses," Welsh Plant Breeding Sta. Bull., H. No. 3, p. 5.

2 The methods of conducting the stem and leaf separations were precisely similar to those previously described. See Stapledon, R. G., *loc cit.*

3 See footnote on page 112.

Discussion of Results.

It is not necessary to burden this brief account of the work with detailed tables, consequently most of the yield results will only be presented on a percentage basis.

"TILLER BED" RESULTS. B. 139 I. In this experiment only sodium nitrate was tested. The average results based on weights of oven dried material for the five strains under test are set out in Table I.

TABLE I.

To show the average yields given by five strains of Cocksfoot treated with sodium nitrate compared to the control (unmanured) put at 100. The percentage leaf, together with the relative number of panicle bearing shoots, is also shown.

Treatment.	Yield data.			
	Hay.	Aftermath.	Pasture. Sum. of 6 cuts.	Sum. of H. A. and P.
Unmanured ...	100	100	100	100
Sodium Nitrate ...	162	99.6	126	135

Treatment.	Per cent. leaf in			Relative number of pan. bearing shoots.	
	Hay.	Aftermath.	Pasture.	Hay.	Pasture.
Unmanured ...	22.5	72.5	68.4	100	100
Sodium Nitrate ...	21.5	75.7	61.7	109	130

The sodium nitrate gave substantially increased hay yields in the case of all the strains; the effect was, however, uniformly negligible in the aftermath, and in one case was not very apparent in the pasture. The ratio of the sum of the hay and aftermath cuts to the sum of the six pasture cuts was very similar to that given by previous trials and since the greatest increase from nitrate was shown in the hay the ratio was even less in favour of the pasture cuts on the manured than on unmanured plots. The ratios were as follows:—

Unmanured ... Hay + Aftermath 100: Pasture 57.7
Sodium Nitrate ... Hay + Aftermath 100: Pasture 48.7

The effect of the sodium nitrate on the aggregate pasture yield was chiefly the result of the greatly increased weights given by the first two cuts (end of May and end of June).

It is of considerable interest to note that although the plots treated with nitrate gave higher yields of leaf than the unmanured, the yield of stem was proportionately increased, thus the percentage leaf in

hay was no greater on the nitrate than on the unmanured plot. In the aggregate produce of the pasture cuts, the unmanured would seem to have given an appreciably higher percentage of leaf than the nitrate plots.

As has been previously shown,[4] the stem to leaf ratio in both hay and pasture is considerably influenced by the "stem shoot" to "leaf shoot" ratio, and it is therefore worthy of note that in both the case of hay and pasture produce the number of panicle bearing shoots was greater per unit of area on the nitrate than on the unmanured plots. This is also a point of considerable importance in relation to seed production and will be discussed in more detail when dealing with the propagant data.

If the number of panicle bearing shoots per unit of area in the hay is compared with the number occurring in the aggregate of the pasture cuts (almost wholly in the May and June cuts) it is found that repeated cutting occasions a decrease on manured and unmanured plots alike. The average reduction for the manured and unmanured plots together has amounted to 18 per cent.

B.56 VI. In this trial, unlike the last, the sodium nitrate was applied to beds on a soil deficient in phosphate and not recently manured with a phosphatic dressing.

Superphosphate alone, as well as nitrate alone, was tested in this case. Only the unmanured plots were duplicated for each strain and owing to the sloping and somewhat variable nature of the ground it was found impossible to obtain reliable yield data. It was evident, however, that the nitrate had occasioned considerable increases in the hay yield on several of the plots, although the average increase from all the plots was no more than 12 per cent. The superphosphate, however, only showed an increase in hay yield on three out of eleven plots—this lack of action of superphosphate is probably significant in view of the data presented in the subsequent section.

Samples were carefully taken from the hay plots on June 21th, and the percentage dry matter ascertained on the aggregate produce. Not only was it found that on average figures the hay from the differently treated plots gave very similar percentages, but the same was the case when plots which had responded freely to nitrogen were compared with their controls.

The average percentages of dry matter in the green hay for the three strains the plots of which showed the greatest response to

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4 See Stapledon, R. G., and Jones, Rhoda. "Seeds Mixtures for Temporary Grass; Investigations conducted in Denmark and Sweden and observations on Trials of a similar nature in progress at Aberystwyth." This *Jour.*, Vol. I, 1925, p. 60.

nitrogen were as follows, compared to the average of all the plots in the trial (in brackets):

Control	... 26.3 (26.2)
Nitrate	... 26.7 (26.6)
Superphosphate	... 26.3 (26.2)

Thus, although sodium nitrate had occasioned an appreciable average increase in hay yield and a high increase on some plots, in no case was a significant difference in the percentage dry matter of the green hay to be discerned as a result of the treatment.

PROPAGANT RESULTS: B.56 VII. The data from this trial are particularly reliable. Each treatment was tested on forty-two spaced adult propagants, representing twenty-one pedigree plants. The pairs of propagants were set out on the checker board plan—additional propagants being used to serve as "buffers" between the control and treated pairs of propagants and to counter border effect. As in the case of B.56 VI, the trial was set out on soil highly deficient in phosphate and to which no phosphatic manure had been recently applied. Sodium nitrate alone and superphosphate alone were brought under test.

An interesting feature of this trial was the fact that three of the plants under test were badly attacked by *Epichloe typhina*, which as is usual in extreme cases, prevented the plants from developing flowering shoots. The results are given separately in Table II (p. 108) for the normal and for the Epichloed plants.

If the results given in Table II are compared with those in Table I (Tiller beds, B.139 I) it will be observed that they are in substantial agreement. Sodium nitrate has had a marked effect on yield shown chiefly in the hay crop, although in the case of the propagants the pasture increase has come closer to the hay than with the tiller beds and the beneficial influence has also been continued to a slight extent into the aftermath. The lack of action of superphosphate on yield as suggested by the tiller beds (B.56 VI) is abundantly confirmed by the propagants, and taking the evidence as a whole a slight reduction in yield is indeed implied.

The increased yield given by nitrogen over the control in the pasture cuts was accounted for chiefly in the second and third cuts (June 3rd and July 8th), which showed an increase respectively of 34 per cent. and 24 per cent.; the last cut (October 13th) gave practically the same weight of produce for control and nitrogen.

All the pedigree plants, except two, gave a substantial response to nitrogen in the hay, the greatest increase being 90 per cent.; all

the plants, except one, showed appreciable benefit in the pasture cuts, but six (out of twenty-one) failed to yield increased aftermath.[5]

It will be seen that the addition of sodium nitrate has had little material effect on the percentage of leaf in the produce of either hay, aftermath or pasture, although as with the tiller beds there is a suggestion, albeit in this case less well marked, of a slightly higher percentage of leaf in the unmanured pasture. The point of interest is, however, that sodium nitrate, although exerting an unmistakable influence on yield, has been without effect in the matter of increasing the proportion of leaf to stem. Superphosphate, like sodium nitrate, has been without material effect on the stem to leaf ratio.

It will be noted that in the case of the propagants, sodium nitrate has not increased the number of panicle bearing shoots to the same extent as on the tiller beds, although both in the case of hay and pasture a slight increase was apparent.

The chief points of interest in connection with the Epichloed plants are (1) the high percentage of leaf in the hay, due of course to the non-development of panicles; (2) the more considerable relative response to sodium nitrate in both hay and aftermath than that made by the normal plants; and (3) the quite evident reduction in percentage leaf in response to nitrate in hay, aftermath and pasture alike.

Apart altogether from the influence of manures, it will be observed that the ratio of the sum of hay and aftermath to the sum of the pasture cuts is again of the same order as that noted for the tiller beds and in confirmation of the numerous results previously reported.[6]

The ratios given at the foot of Table II show, moreover, that neither sodium nitrate nor superphosphate are competent to increase the pasture yield relative to the hay. The slightness of the counter-

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[5] The response to sodium nitrate of the three main types of Cocksfoot under test as illustrated by the hay yields is well shown by the statement hereunder:—

Dense Pasture (the most densely leafy and close growing type). All the plants responded freely. The average increase in yield was 40 per cent. and the most pronounced increase was 90 per cent.

Tussocks (dense and leafy, but taller and larger growing than "dense pasture"). All the plants responded to the treatment, although a few but slightly. The average increase in yield was 29 per cent., the most pronounced increase was 90 per cent.

Widely Spreading and Fanned (large plants with very spreading habit in early stages and less leafy than the above types). Two plants gave no response. The average increase in yield was 10 per cent., and the most pronounced increase was 33 per cent.

The above results were very similar in the case of the "tiller beds," the dense pasture having responded more freely than other indigenous types or than the Danish control.

[6] See Stapledon, R. G., *loc. cit.*

TABLE II.

To show relatively the yield and other data from propagants of Cocksfoot treated with Sodium Nitrate alone and with Superphosphate alone.

Treatment.	Yield data.			Per cent. leaf in			Relative number of panicle bearing shoots in		Data relative to Seed Production.			
	Hay.	Aftermath.	Sum of 5 pasture cuts.	Hay.	Aftermath.	Pasture.	Hay.	Pasture.	Yield of dressed seed.	Percent. of heavy seed in sample.	Germ. of heavy seed per cent.	Wt. per 1000 heavy seed in gm.
					Normal Plants.							
Unmanured ...	100	100	100	14.1	76.2	63.0	100	100	100	46.7	74	.67
Sodium Nitrate ...	127	107	120	15.1	73.4	60.0	102	101	155	49.7	78	.71
Superphosphate ...	99	93	98	14.4	75.1	61.0	94	92	96	45.4	74	.69
					Plants attacked by Epichloe typhina.							
Unmanured ...	100	100	100	68.5	76.8	88.0	—	—	—	—	—	—
Sodium Nitrate ...	149	125	118	65.5	71.9	85.0	—	—	—	—	—	—
Superphosphate ...	93	90	108	68.8	79.5	88.0	—	—	—	—	—	—

Ratio of sum of Hay and Aftermath to sum of Five Pasture cuts on Normal Plants.

Unmanured ...	100 : 52.
Sodium Nitrate ...	100 : 51.
Superphosphate ...	100 : 52.

balancing effect of manures to the influence of a system of pasture cutting is well indicated by comparing the sum of the hay and aftermath from the unmanured plants with the sum of the five pasture cuts from the plants treated with sodium nitrate—this gives a ratio of 100 : 62, compared with 100 : 51, when both hay and pasture plants have received sodium nitrate.

It is thus perfectly evident that the stimulating effect of sodium nitrate has not been nearly sufficient to very appreciably counterbalance the depressing influence of a system of pasture cuts even when only five cuts were taken during the growing season.

It will be seen from Table II that sodium nitrate has been competent to materially increase the yield of seed and that here again superphosphate alone has been without beneficial result. Sodium nitrate as well as reacting favourably on the yield of seed as such would seem also to have been responsible for producing seed of a slightly heavier grain weight, higher germination and higher proportion of "heavy" to "light" seed than superphosphate alone or than the control.[7]

The Effect of the Manures on Root Development and on Subsequent Growth.

In order to ascertain whether sodium nitrate or superphosphate had exercised any residual influence on the plants respectively treated as hay and pasture during 1924, the produce was allowed to grow on from the autumn until April 21st, 1925, when the herbage was cut and weighed. Shortly afterwards, the plants were carefully dug up and dried, the roots being subsequently separated from the soil and weighed.

The essential results relative to root weights and herbage produced are set out in Table III.

In the first place it may be remarked that as in previous trials the plants yielding hay and aftermath gave far more growth early in the spring of the following year than those previously subjected to pasture cuts. The additional yield from the hay plants over the pasture, regardless of manurial treatment, in nearly all cases amounted to over 20 per cent., and in some instances was as high as 100 per cent., no single pasture plant yielding as heavily as its corresponding hay plant.

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[7] In an experiment on Tall Fescue (grown in rows) Ammonium Sulphate alone had increased the yield of seed, but not to the same extent as noted above for Cocksfoot. In the case of Tall Fescue the quality of the seed (grain weight and germination) was uninfluenced by the dressing.

TABLE III.

To show on propagants differently treated during 1924 (1) the relative weight of produce on April 21st, 1925, and (2) weight of roots in gm. per single propagant.

	Relative weight of produce April 21st, 1925.		Weight of roots in gm. per single propagant.	
	Hay. 1924.	Pasture. 1924.	Hay. 1924.	Pasture. 1924.
Unmanured	100	100	11.0	8.4
Sodium Nitrate	107	98	11.9	8.7
Superphosphate	83	96	10.5	8.5

In the matter of root development also the advantage was unmistakably with the hay plants. In many cases the pasture propagants gave as much as 30 per cent. less root than the hay plants, and in a few cases the difference amounted to 100 per cent., but on the average the reduction of root shown by the pasture plants, although considerable, was slightly less than that shown by previous experiments. It is of considerable interest, however, that the pedigree strains showed a wide range of response to continued cutting, some plants resisting the treatment in a manner vastly superior to others.

If the yielding ability as a whole of the eighteen non-epichloed plants is compared with each other and with the bulk of their individual root systems it is to be noted that yield is not very definitely correlated with extent of root system. Thus the four plants giving strikingly heavy root systems would have been placed as follows on a scale of yield based on the sum of hay, aftermath and pasture:—

Plant with heaviest root system was fifth on scale of yield.
Plant with second root system was fifteenth on scale of yield.
Plant with third root system was seventeenth on scale of yield.
Plant with fourth root system was first on scale of yield.

The average weight of roots of the nine heaviest yielding plants was, however, appreciably in excess of the average of the nine lowest yielding, the figures being 10.4 gm. and 9.2 gm. per plant (average of hay and pasture propagant) respectively.

The results presented in Table III show that neither sodium nitrate not superphosphate have had any material influence in assisting the pasture propagants to resist the cutting treatment—the root development has not been appreciably increased by either dressing, while the yields have actually been less than those given by the unmanured plants.[8] The hay plants manured with sodium nitrate would seem,

[8] Up to the present it has not been possible to subject root development to critical investigation and it must be borne in mind that weight of root can not of itself be regarded as a satisfactory measure of root activity.

however, to have shown a residual benefit from the treatment, for they have given seven per cent. higher yield than the untreated, and this increased yield has been associated with a slightly increased root development. The hay plants treated with superphosphate have shown no residual benefit either in early spring yield or in root development.

Summary and General Conclusions.

(1) The trials here reported have been of a preliminary nature and it seems desirable to test the action of inorganic nitrogenous dressings in more detail. In future experiments it is proposed to manure a series of plots with a uniform dressing of phosphates and potassic fertilizers and to add to different units a graded range of strengths of sodium nitrate, as it is thought that by this means the action of inorganic nitrogen will be the better and more accurately tested.

(2) The present trials have confirmed the earlier work as showing that repeated cutting during a current season gives rise to an aggregate bulk of produce considerably less than that developed from the sum of a hay and aftermath crop. The influence of repeated cutting has also been to reduce the number of panicle bearing shoots by an amount varying from 8 to 18 per cent, to reduce the root systems of the plants so cut, and to retard the growth produced early in the following spring. Different strains of Cocksfoot have, however, reacted very differently to the treatment—some of the strains showing relatively slight reduction in root systems compared to that of average plants.

(3) Superphosphate has been without material quantitative or qualitative benefit, no increase of yield has followed its application in the case of either hay, aftermath, pasture or seed production. The root development does not appear to have been favoured by this manure, while the stem to leaf ratio in the produce of hay, aftermath and pasture alike has not been substantially affected.

(4) Sodium nitrate has had a considerable quantitative influence which has shown itself most markedly in the hay crop. In the case of quite a number of plants the effect has also continued into the aftermath, and to a slight extent into the early spring of the year following its application. Sodium nitrate has also reacted appreciably on the yield from a system of pasture cuts—the greatest increase, however, showing itself in the two or three first cuts; the benefit is lost by the last cut and has not followed into the spring of the subsequent year. Both the yield and quality of the seed harvest have been benefited by application of sodium nitrate.

The several strains of Cocksfoot under test have responded very differently to sodium nitrate, the "dense pasture" plants having shown the greatest increase in yield.

(5) Since sodium nitrate has exercised such definite quantitative influences it might have been expected that substantial qualitative differences would also be apparent. Under the conditions of the present trials neither the percentage dry matter in green hay nor the stem to leaf ratio have been materially influenced. Under pasture cutting if anything sodium nitrate has actually increased the ratio of stem to leaf, but the difference is probably not sufficient to be of much significance. The chemical analyses conducted by Fagan and Evans have, however, shown important differences in composition between the control plants anl those manured with nitrate of soda.[9]

(6) It is a matter of considerable significance that neither sodium nitrate alone nor superphosphates alone have been competent to materially counteract the depressing influence of repeated pasture cuttings, and this equally whether the effect is judged by the growth during the current season, early in the following season, or by the root development of the repeatedly cut plants.

Even the unmanured hay plants have been vastly superior to the manured pasture plants in each of the above respects, although, of course, compared on this unfair basis, the ratio "hay" to "pasture" has been somewhat improved in favour of "pasture" in each case.

(7) It must be emphasised that the present trials have been conducted on a quick and early growing species of grass, and although carried out on well-established and adult plants, the plants have probably not been nearly as old or as well-established as those normally met with on a real old permanent pasture. It follows, therefore, that the results here presented can not necessarily and as such be taken as applicable to the species in general contributing to the herbage on permanent grass or to the conditions associated with a fully developed mixed and adult sward.

Experiments of the type under review are of course analogous to laboratory experiments and it is no more legitimate to generalise with any justifiable assurance as to agricultural practice from the results of the one class of investigation than from the findings of the other. The first aim of critical investigation must be to elucidate

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9 See Fagan, T. W., and Evans, R. E. "The Influence of the Application of Superphosphates and Nitrate of Soda on the Chemical Composition of the Stem and Leaf of Pasture Cuts in Cocksfoot," p. 113 of this volume of the Journal. The two papers are complementary to each other and should be considered together.

fundamental principles; and to help towards such an understanding of the factors influencing farm practice that it may become possible to design no less critical field trials competent to test the effect of every factor separtely under normal farm conditions. It is this last necessity which probably presents to the agricultural scientist at once the most difficult, the most interesting and the most important of all the problems encountered in connection with any particular line of investigation.

THE INFLUENCE OF THE APPLICATION OF SUPERPHOSPHATE AND NITRATE OF SODA ON THE CHEMICAL COMPOSITION OF THE STEM AND LEAF OF PASTURE CUTS OF COCKSFOOT.

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The pooled produce from the pasture plants of Experiment B.56 VII,[1] one of the experiments discussed by Stapledon and Beddows in a separate paper (see p. 103 of this volume), was passed on to us for chemical examination, with the object of ascertaining what effect the manurial treatment under the conditions of the experiment had on the chemical composition of the herbage.

As already indicated, the pooled pasture plants were separated into stem and leaf, which were independently examined.

Those familiar with current agricultural literature are aware that at the present time much more importance is attached to the mineral constituents of a foodstuff than has formerly been the case. We therefore determined a few of the more important of these in addition to making the usual determinations that are generally made in a foodstuff.

The cultural and manurial treatment the different plants received have already been fully discussed in the previous paper, to which this is only an addendum. It is, therefore, unnecessary to say anything further on these points.

Table I gives the result of the chemical analysis of the pooled stems and leaves of the plants respectively.

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1 The produce from the five separate pasture cuts for each of the twenty-one pedigree plants was thoroughly mixed together (stem and leaf being kept separate) and representative samples of the bulks thus compounded were drawn for the purpose of the chemical analyses.

TABLE I.

Showing the percentage chemical composition (dry matter) of the pooled produce of the "pasture cuts" from Indigenous Cocksfoot in Experiment B.56.VII.

		Ether Extract.	Crude Protein.	True Protein.	Fibre.	Ash.	Soluble Carbo-hydrates.	Silica SiO_2	Phosphoric Acid P_2O_5	Calcium Oxide CaO	Oxide of Iron. Fe_2O_3	Chlorine Cl.	Nitrogen. N.
Control	Stem	2.13	10.31	8.69	31.38	12.05	44.13	3.68	0.98	0.574	0.103	0.143	1.65
	Leaf	3.55	18.25	15.13	26.60	13.30	38.30	4.92	0.91	0.847	0.097	0.124	2.92
Superphosphate	Stem	2.42	11.44	8.69	35.02	11.45	39.67	4.03	0.91	0.588	0.112	0.077	1.83
	Leaf	3.53	18.44	16.13	28.55	13.55	35.93	5.45	0.91	0.868	0.103	0.070	2.95
Nitrate of Soda	Stem	2.42	12.63	10.06	34.57	11.57	38.81	3.95	0.86	0.476	0.111	0.147	2.02
	Leaf	3.25	20.06	17.56	29.52	12.57	34.60	4.05	0.84	0.770	0.103	0.125	3.21

It will, we think, facilitate the discussion of these results if they are considered under two separate headings:—

(*a*) A comparison of the composition of the stem and leaf irrespective of manurial treatment.

(*b*) The effect of the manurial treatment on the composition of the stem and leaf.

A considerable amount of work has been carried out in connection with the investigations in progress at the Welsh Plant Breeding Station, Aberystwyth, on the composition of stem and leaf, and the results of some of these have already been published.[2] The data presented in Table I indicate the marked superiority of the leaf over the stem, and fully confirm the results already referred to.

The superiority in composition of the leaf over the stem is seen in the higher percentage of protein both true and crude, as well as the lower amount of fibre in the leaf. The ratio also of the true to crude protein is generally higher in the leaf than it is in the stem. Further, the percentage of ash and silica in uniformly higher in the leaf than it is in the stem, but the phosphoric acid, on the other hand, is very slightly higher in the stem than in the leaf.

A comparison of the percentage of lime in the dry matter of the leaf and stem is very striking, the former containing approximately one and a half times as much as that found in the stem. Equally striking is the ratio of phosphoric acid to lime in the stem and leaf, in the former this ratio is approximately 1:0.5, whereas in the latter it is nearer 1:1.

This again, from the point of view of a balanced mineral ration shows the marked superiority of the leaf over the stem. In the case of their iron and chlorine content, however, the stem is slightly superior to the leaf.

The effect of the addition of superphosphate on the composition of the stem, apart from an appreciable increase in the fibre content is small. The figures further suggest as a result of its application an increase in the percentage of crude protein, silica and lime, with a considerable depression in the percentage of chlorine. Its effect on the leaf is very similar to that on the stem, with the exception that the percentage of crude protein is little affected.

The application of the nitrate of soda has influenced both stem and leaf in a similar manner, the crude and true protein as well as the

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2 See Fagan, T. W., and Jones, H. Trefor. "The Nutritive Value of Grasses as shown by their Chemical Composition." Welsh Plant Breeding Station *Bull. Ser. H*, No. 3, June, 1924.

fibre being considerably increased, while the percentage of phosphoric acid and lime appear to be adversely affected by this manure.

The one outstanding result of the chemical examination of the produce is the increase in the percentage of the true and crude protein that follows the application of nitrate of soda. This is of special interest when the increase in yield, which is also obtained with nitrate of soda, is taken into consideration.

Before the result of different manurial treatments on grasses can be fully ascertained, it will be necessary, as already pointed out by the authors of the main paper, to extend trials such as these so as to eliminate the influence of soil and season.

THE EFFECT OF THE DATE OF "PUTTING UP" TO HAY ON THE SEVERAL SPECIES CONTRIBUTING TO THE SWARD OF A TEMPORARY LEY.

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The effect of the date of "putting up" to hay on the yield of the crop has been the subject of investigation at the Plant Breeding Station since 1921, and results obtained during the three years 1921-23 have been reported upon.[1] Trials again conducted in 1924 confirmed the earlier results,[2] but seemed to indicate that the extent of the differences in yield obtained between plots "put up" say in February or early in March and those grazed until the end of April were determined in no small degree by the original botanical composition of the sward—or, in other words, that the different dates of "putting up" reacted differentially on the various elements of the herbage.

It was therefore decided to investigate the matter from this point of view during the harvest season of 1925. Two leys on the Spring Field in their second harvest year (E.36) were regarded as being

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1 See Stapledon, R. G., and Williams, R. D. "Seasonal Productivity of Herbage Plants in General Use." Welsh Plant Breeding Station Bulletin, Series H, No. 1. 1922, p. 21, and Stapledon, R. G. "The Seasonal Productivity of Herbage Grasses." *Ibid* Series H, No. 3. 1924, p. 38.

2 In 1924 in the case of a ley in its first harvest year, plots "put up" early in March showed an increase of 13 per cent. in yield over those "put up" towards the end of April.

very suitable for the purpose. The chief reasons for selecting these leys were that they had been under critical investigation during the first harvest year (1924),[3] and that the swards still consisted very largely of Italian Rye Grass—a species which it seemed particularly desirable to investigate.[4]

The field in question had been divided into two approximately equal areas sown respectively with the following mixtures (in lb. per acre) early in May, 1923:—

		Mixture A.	*Mixture B.*
Italian Rye Grass	...	6.0	6.0
Indigenous Cocksfoot	...	13.5	—
Commercial Cocksfoot	...	—	13.5
Indigenous Tall Oat Grass	...	3.5	—
Commercial Tall Oat Grass	...	—	3.5
Indigenous Tall Fescue	...	2.2	—
Commercial Tall Fescue	...	—	1.4
Montgomery Red Clover	...	4.5	—
Chilian Broad Red Clover	...	—	4.5
Wild White Clover	...	1.0	—
Dutch White Clover	...	—	1.0
		30.7	29.9

Each area, A and B (referred to hereafter respectively as "Indigenous" and "Commercial") was sub-divided into a number of plots, of no particular dimensions, but so that each was situated on ground of a reasonably similar character. Six plots on each area were "put up" for the 1925 hay harvest at various dates, ranging from the 1st November, 1924, to 1st May, 1925. Two had been kept as hay in 1924, whilst the others were pastured. The remainder of the field was again grazed in 1925; all grazing was by sheep—Kerry and Suffolk ewes and lambs being employed.

The schedule hereunder gives the details of time of "putting up" the several plots:—

A. and B.	Plot 1. 1924, Hay put up March, 1924:	1925, Hay put up 1st November, 1924.
A. and B.	Plot 2. 1924, Hay put up April, 1924:	1925, Hay put up 1st November, 1924.
A. and B.	Plot 3. 1924, Pastured.	1925, Hay put up 1st November, 1924.
A. and B.	Plot 4. 1924, Pastured.	1925, Hay put up 1st February, 1925.
A. and B.	Plot 5. 1924, Pastured.	1925, Hay grazed to 1st February, 1925. Rested to 1st April. Grazed during April. Put up to hay, 1st May, 1925.
A. and B.	Plot 6. 1924, Pastured.	1925, Hay put up 1st May, 1925.

[3] See Stapledon, R. G. "The Improvement of very poor Pastures by Ploughing and Immediate Re-Seeding." *Jour. Min. of Agr.*, Vol. XXXII, No. 1. April, 1925, p. 13.

[4] All the trials in progress at the Station combine to show that if Italian Rye Grass is cut for hay at or before the commencement of flowering or is grazed during the first harvest year that it carries over in very considerable quantity into the second harvest year.

In order not to complicate the investigation unduly, all the 1925 hay was cut on the same date—on June 20th.

Five accurately cut and spaced quadrats (each 1/500th acre) were taken on each plot and the produce from these weighed. Accurate representative samples were taken of the hay within the quadrats for each plot, one sample being kept for "air dry" hay estimation and one sample for botanical analyses. Average heights to apex of inflorescence and also to the upper ligule of the stem were taken on all plots in the case of Italian Rye Grass and of Cocksfoot. As soon as possible after the removal of the hay crop, counts of plants of the sown grasses and of Red Clover[5] were made on each plot according to the technique of ground analysis followed at the Station.[6]

Additional data were also obtainable from a number of simple mixtures sown on the Lane Field (E.52.I). These were sown in 1924 and were therefore in their first harvest year. The principle of this experiment was to sow Wild White Clover with one major grass species, and in separate plots to include also (1) Italian Rye Grass, and (2) Italian Rye Grass and Montgomery Red Clover. In the case of a number of the mixtures half of the plot was "put up" for hay on February 1st, 1925, and the other half was grazed on until May 12th. The Crested Dogstail plots will be used as the best examples in connection with the present investigations. The mixtures (in lb. per acre) were as follows:—

Plot I.	Italian Rye Grass	... 5 lb.
	Montgomery Red Clover	... 4 lb.
	Wild White Clover	... 2 lb.
	Crested Dogstail	... 20 lb.
Plot II.	Italian Rye Grass	... 5 lb.
	Wild White Clover	... 2 lb.
	Crested Dogstail	... 20 lb.
Plot III.	Wild White Clover	... 2 lb.
	Crested Dogstail	... 20 lb.

The hay from all the plots was cut on June 29th, and in this case the weights given represent green produce.

Discussion of Results.

Detailed notes taken on the plots on the Spring Field previous to cutting, clearly demonstrated that in the case of both Indigenous and Commercial the hay from Plots 5 and 6 was preponderantly leafy

5 It was not possible to make accurate counts of the White Clover.
6 A full report of the methods adopted for conducting herbage analyses in general at the Station will be published at an early date.—R.G.S.

and "grass like," that from Plots 1, 2 and 3 was much more stemmy and taller in growth. The hay on Plot 4 was intermediate, though approaching more nearly to Plots 1 to 3 than to Plots 5 and 6.

The chief quantitative data obtained from the plots representing the several treatments on the Spring Field are set out:—in Table I, showing the air dry hay weights of the sown species; in Table II, showing the average heights of Italian Rye Grass and Cocksfoot in the hay; and in Table III, showing the number of plants of the sown species per unit of area. The data from the Lane Field are shown in Table A.

TABLE I.

To show the air dry hay weights of sown species and of miscellaneous plants in lb. per 1/100th acre. Spring Field, 2nd harvest year, 1925.

Plot.	Italian Rye Grass.	Cocksfoot.	Tall Oat Grass.	Tall Fescue.	Red Clover.	White Clover.	Mis. Plants.	Total Produce.
		A. Indigenous Mixture.						
1.	12.3	9.0	4.4	1.3	6.4	0.8	16.2	50.4
2.	15.6	9.3	3.1	2.2	4.4	0.4	19.6	54.6
3.	12.2	8.5	3.7	1.4	6.0	1.2	20.2	53.2
4.	7.9	11.2	3.8	1.0	6.9	2.1	18.7	51.6
5.	2.9	12.2	1.5	1.3	7.8	3.8	16.9	46.4
6.	2.9	14.2	2.1	1.5	7.4	3.5	18.6	50.2
		B. Commercial Mixture.						
1.	10.3	9.4	2.1	0.2	0.9	0.4	21.7	45.0
2.	6.2	6.0	0.3	3.3	1.1	0.4	19.9	37.2
3	5.4	4.0	0.5	3.1	0.9	1.3	18.7	33.9
4.	4.2	5.7	0.5	1.6	0.2	1.6	21.1	34.9
5.	2.6	4.9	T	0.7	0.3	0.9	10.4	19.8
6.	3.1	7.4	0.2	0.2	0.3	0.9	11.1	23.2
	A plus B. Average of Indigenous and Commercial Mixtures.							
1.	11.3	9.2	3.3	0.8	3.7	0.6	19.0	47.9
2.	10.9	7.7	1.7	1.8	2.8	0.4	19.8	45.1
3.	8.8	6.3	2.1	2.3	3.5	1.3	19.5	43.8
4.	6.1	8.5	2.2	1.3	3.6	1.9	19.9	43.5
5.	2.8	8.6	0.8	1.0	4.1	2.4	13.7	33.4
6.	3.0	10.8	1.2	0.9	3.8	2.2	14.9	36.8
	Average of Grouped Plots: Indigenous and Commercial Mixtures.							
1 + 2.	11.1	8.4	2.5	1.3	3.2	0.5	19.4	46.4
1 + 2 + 3.	10.3	7.7	2.4	1.6	3.3	0.8	19.4	45.5
4.	6.1	8.5	2.2	1.3	3.6	1.9	19.9	43.5
5 + 6.	2.9	9.7	1.0	1.0	4.0	2.3	14.3	35.2

(*a*) Total Yield of Produce (= air dry hay) : E.36.

It is interesting to find (see Table I) that the total yield of hay has not dropped very appreciably on the late "put up" plots in the case of the indigenous mixture, whilst the fall in total yield is

very material in the corresponding plots of the commercial mixture. The reason here is undoubtedly to be sought in the fact that the indigenous grasses and the Montgomery extra late Red Clover being comparatively late to start growth in the spring were not making active headway until towards the end of April or early in May, and hence were only grazed to a limited extent. The commercial counterparts on the other hand were already in active growth during the latter half of April and were thus at that period extremely palatable to sheep and were correspondingly heavily grazed. Further, the growth of Italian Rye Grass was greater on the indigenous area, and on the strength of very careful observations made on the plots at the time it seems legitimate to suggest that the presence of an increased amount of this grass may have acted as a protection to the other constituents of the herbage—Italian Rye Grass being at once the most palatable and most productive constituent of the herbage at that period.

The above conclusions derive substantial support from the earlier investigations at the Station, which have tended to show that cutting a plant at the critical early stage when growth has fairly begun, tends to retard the subsequent growth of that plant.[7]

It is also interesting to note that the yield of Plot 5 is lower than that of Plot 6 in both mixtures, and not only is the total bulk greater on the latter plot but most of the species concerned have given an increased yield. It is at first sight difficult to explain such an occurrence, but it is probable that the February-March rest given Plot 5 caused the production of a fresher and more succulent growth of herbage than was available on the continuously grazed Plot 6, with the result that when sheep were turned in again in April they then grazed the sward of Plot 5 correspondingly harder than that of the un-rested Plot 6.

An analagous case was shown by the behaviour of the sheep when turned into the field some little time after all the hay plots had been harvested. The sheep were then given a free run of both the area (which had been all the season under pasture and of the hay area—that is to say of pasture grass and of aftermath grass. Although the herbage was seemingly of equal succulence on both pasture and aftermath the flock as a whole confined their attention almost

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[7] See Stapledon, R. G. "The Seasonal Productivity of Herbage Plants," *loc. cit.*, and refer to the section dealing with "The effect of the date at which a system of cutting is started on the aggregate yield obtained during a current season," pp. 38—44. Subsequent investigations with pure species plots now in progress seem to indicate quite clearly that grazing with sheep has a very similar influence to cutting.

exclusively to the aftermath, which they grazed bare before turning their attention to the pasture. The preference for the aftermath has moreover been maintained to the time of writing (middle of September) and it is now far more closely grazed than the pasture.[8]

It will be noted from the average figures given at the bottom of Table I that there has been no appreciable difference in yield between plots " put up " in November and those " put up " in February; this is in keeping with former results and tends to confirm previous conclusions, namely, that grazing at the time of the year when the plants are making little or no growth exercises but a negligible influence on subsequent vigour.

E.52.I. It is interesting, however, to compare the above results with those obtained on the Lane Field, where plots in their first harvest year were " put up " to hay respectively on February 1st and as late as May 12th. On the average of all the mixtures, the yields from the February " put up " were nearly 1/3rd as heavy again as those of the May 12th " put up." It is evident, therefore, that grazing far into May exercises a very marked influence on hay yield, and taking the evidence as a whole it would thus seem that every week of postponement in " putting up " to hay after early April is likely to exercise a progressively exaggerated influence on the hay yield.

The figures in Table A (see p. 124) show, however, that much depends upon the component species of the mixture, at least when the mixture is a very simple one, for in the case of a plot sown only with Wild White Clover and Crested Dogstail—both late species to start active growth in the spring—the yield from May " put up " has come surprisingly close to that of the February " put up."

(*b*) Behaviour of Individual Species in the Hay.

(1) *Italian Rye Grass.* The effect of the various treatments on Italian Rye Grass was very marked on the plots on the Spring Field. In Plots 1, 2 and 3 (early " put up ") this grass was by far the most conspicuous part of the hay crop, whilst in Plots 5 and 6 (late " put up ") it had fallen to a relatively unimportant position. It is significant that Italian Rye Grass shows a decrease in amount of produce as from Plot 1 to Plot 6 (Table I), the greatest drop being from Plot 3 to Plots 5 and 6; Plot 4 being intermediate. The height of the plants of Italian Rye Grass (see Table II) also shows that the most considerable difference is from Plot 3 to Plot 5.

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8 Similar preferences have been noted in the case of pastures run over with the mowing machine (a standard practice at the Station) and then given a suitable (not too long) period of rest.

TABLE II.

To show the average height in cms. of plants in hay. (*a*) to ligule of flag (= upper) leaf and (*b*) to apex of panicle for Italian Rye Grass and Cocksfoot. Average of Indigenous and Commercial Mixtures (100 readings per plot). Spring Field, 2nd harvest year, 1925.

Italian Rye Grass.			Cocksfoot.		
Plot.	(*a*) Upper ligule.	(*b*) Apex	Plot.	(*a*) Upper ligule.	(*b*) Apex
1.	51.0	80.2	1.	63.2	85.8
2.	50.2	79.0	2.	61.4	84.5
3.	46.8	73.6	3.	57.3	78.8
4.	46.7	72.1	4.	55.4	78.9
5.	32.5	54.7	5.	44.0	67.3
6.	33.9	52.9	6.	45.5	68.8

TABLE III.

To show the number of plants per unit of area in the case of the sown species only. Data per 30 mesh readings: 6″ × 6″. Spring Field. 2nd harvest year, 1925.

Plot.	Italian Rye Grass.	Cocksfoot.	Tall Oat Grass.	Tall Fescue.	Red Clover.
		A. Indigenous Mixture.			
1.	50	108	23	14	25
2.	57	128	10	19	54
3.	93	141	22	7	44
4.	52	136	17	13	48
5.	16	145	7	18	36
6.	20	109	5	10	33
		B. Commercial Mixture.			
1.	26	94	5	19	2
2.	30	98	6	6	2
3.	43	90	1	10	—
4.	28	92	—	14	—
5.	32	87	1	14	2
6.	19	82	—	13	2

Productivity data and plant counts per unit area (see Table III) combine to indicate that late spring grazing severely restricts the number and also the size of Italian Rye Grass plants, this effect has perhaps been slightly exaggerated in the present trial by the fact that the plants were in their second year. The plots on the Lane Field (E.52), however, show that even in the first harvest year the number of plants of Italian Rye Grass tends to be very considerably reduced by prolonged grazing. The results hereunder may be regarded as typical and show that "putting up" towards the middle of May has been competent to nearly half the number of plants in the hay compared with "put up" in February.

Number of Italian Rye Grass Plants per 20 mesh readings, 6" × 6". Average of two plots with 10 readings per plot. First harvest year, 1925.

Put up to hay, 1st *February,* 1925.	*Put up to hay,* 12*th May,* 1925.
39 plants.	22 plants.

Comparing Italian Rye Grass with the other species in the mixture (Spring Field), it is important to note that the Rye Grass, unlike most of the other species, shows a marked falling off in productivity and in number of plants per unit of area as between November "put up" and February "put up." Although of course in the case of this grass also the greatest difference is between the February and May "put up" plots. It is Italian Rye Grass, almost alone of all the species, that makes really appreciable growth during the November-February period, and therefore, relative to other species, it is Italian Rye Grass that suffers the most by heavy grazing at this period.

TABLE IV.

To show the Actual Contribution to air dry produce of Italian Rye Grass, Cocksfoot and "other plants" from sub-plots cut on April 24th. Weights (in lb. per 1/100th acre. Spring Field, 2nd harvest year, 1925.

Plots. A.	Italian Rye Grass.	Cocksfoot.	Other Plants.	Total Produce.
Ind. 1.	6.6	0.8	1.0	8.4
Ind. 2.	6.6	0.5	1.0	8.1
Ind. 3.	4.8	0.9	1.4	7.1
Ind. 4.	1.1	0.4	0.7	2.2

This fact is clearly indicated by the data presented in Table IV, which give analyses of the produce cut on sub-plots on the Indigenous area on April 20th, 1925. The comparison is essentially between plots "put up" in November (A 1, 2, 3) and the plot "put up" in February. It is seen that at the end of April not only does Italian Rye Grass far surpass the other species for the production of dry matter per acre, but that Italian Rye Grass, relative to its inherent productivity, has suffered to the greatest extent from being grazed during the period November to February (cf. A 1, 2, 3 and A 4). The Italian Rye Grass on the "put up" February plot (A 4) has given less than 1/5th of the produce of the "put up" November plots (A 1, 2, 3), while the produce of Cocksfoot and of "other plants" has hardly been reduced to a half.

The figures in Table A (Lane Field) afford further evidence of the effect of continuous grazing on Italian Rye Grass. In this case since the grazing was continued well into May a plant like Montgomery Red Clover would be making considerable or appreciable growth, and would thus during the closing phase of the grazing period suffer equally or almost equally with Italian Rye Grass.

TABLE A.

To show the yield in lb. (green weight) per 1/500th acre quadrat for the several sown species and for Miscellaneous Plants on plots "put up" for Hay respectively on February 1st and May 12th. Lane Field. First harvest year, 1925.

Plot and Mixture.	Italian Rye Grass.	Crested Dogstail.	Montgomery Red Clover.	Wild White Clover.	Miscel. Plants.	Total Yield.
	Put up February 1st.					
Plot 1. The Four. sp.	6.0	10.9	11.3	1.8	2.0	32.0
Plot 2. Mont. Clover excluded	8.8	5.8	—	2.2	3.2	20.0
Plot 3. Dogstail and W. White only	—	14.9	—	6.7	5.4	27.0
	Put up May 12th.					
Plot 1. The Four sp.	0.6	11.8	4.2	0.9	1.5	19.0
Plot 2. Mont. Clover excluded	1.1	10.4	—	1.2	3.8	16.5
Plot 3. Dogstail and W. White only	—	13.0	—	5.0	6.0	24.0

It will be seen, however, that whereas Italian Rye Grass hardly gave 1/8th of the yield on the May 12th "put up" plot, that it did on the February "put up" plot—the Late Flowering Red Clover gave about 1/3rd as good a yield on the May as on the February "put up" plot. This of course suggests that the Italian Rye Grass has been weakened far more than the Clover by the prolonged earlier-in-the-season grazing.

From the evidence given in Table I (Spring Field) it will, however, be obvious that the behaviour of the other species in a mixture is largely affected by Italian Rye Grass. Putting up late as well as subjecting the various species to the detrimental influence of prolonged grazing automatically decreases the amount of competition with Italian Rye Grass to which they will be subjected during the period of hay production. And it is perhaps as much on this account as to the late start in the spring that Indigenous Cocksfoot, Montgomery Red Clover and Wild White Clover have contributed as, or heavier, yields to the hay crop when "put up" on May 1st as when "put up" in November. The data from the Lane Field (see Table A) also illustrate the competitive influence of Italian Rye Grass, for both in the case of the February and May 12th "put up" plots Crested Dogstail and Wild White Clover gave higher yields on the plots from which Italian Rye Grass had been excluded than on those where it had been sown. It is not, however, here easy to assess the influence of date of "putting up" (in relation to intensity of competition with the Rye Grass (on the

plots where this species was included), for the extra period of grazing until May 12th greatly exaggerates the retarding influence of the grazing factor. That the difference in the yields of White Clover, although in favour of the February " put up " is not greater perhaps suggests a certain set-off from reduced competition with Rye Grass assisting the May plot. The differences in regard to Crested Dogstail are not large enough to be of much significance, but it is at least suggestive of slight interference from Italian Rye Grass that the May " put up " contribution of Crested Dogstail has been certainly no less and apparently rather more than the February " put up " while when Italian Rye Grass had not been sown in competition with the Dogstail the higher contribution was from the February " put up " plot. It is apparent, however, from the evidence as a whole that with a late starting and slow growing grass like Crested Dogstail, neither the effect of prolonged grazing as such, nor of competition with Italian Rye Grass as such, is nearly so pronounced as in the case with an earlier starting and quicker growing grass like Cocksfoot.

The data here under consideration show that the aggressiveness of Italian Rye Grass is due very largely to its early start in the spring —growth in this species goes on practically throughout the winter period, especially during mild seasons, such as are normally experienced in Wales. This early set off, coupled with a potentiality for exceptionally rapid growth when more favourable conditions set in, combine to make this grass a most formidable competitor with other species in the hay, or whenever the herbage is permitted unhampered development. This property has militated against the wide use of Italian Rye Grass at least in quantity in what are deemed to be well balanced mixtures.

In many parts of Wales, owing to the great scarcity of early spring keep, it is, however, the normal practice to graze first year's seeds well into April or even into May of the first harvest year. It is, therefore, of interest to find that hill and other farmers who habitually graze first year's seeds far into the spring frequently include large quantities of Italian Rye Grass in their mixtures, and it would now seem that this apparent transgression against the teaching of the " balanced mixture " is in fact amply justified.[9] The

[9] I, for my part, must freely admit that I have always been adverse to the inclusion of large amounts of Italian Rye Grass in long duration mixtures, and in the past have not had the discernment to make reservations in connection with the needs of the man who must have April grazing and who has a predeliction for a " herby " hay. In the past, however, I have not had facilities for conducting critical experiments and there is such a world of difference between opinions based on casual observations and those born of actual experiments.—R.G.S.

Italian Rye Grass provides relatively abundant grazing during the period when it is most urgently needed and at this juncture far from exercising a pronounced competitive effect on the other constituents of the herbage, it rather serves to protect them from being seriously damaged by too hard grazing.

Since the hay is " put up " late, of all the species contributing to the crop it will be the aggressive Italian Rye Grass that will have been hampered most of all (relative to its inherent capacity for growth) by the prolonged grazing, consequently this grass will not dominate the hay. The crop will be light it is true, but it will consist of a leafy clovery product—in fine of a " herby " product so dear to the sheep-master.[10]

One danger there is in adopting the local practice and that is that Italian Rye Grass may completely dominate the position from the very outset in the seeding year. It may do so even in the covering corn crop if that has been unduly light—or if the autumn is a very open one it may do so soon after the harvesting of the corn. It will do so with certainty if the mixture has been sown without a covering crop or under a light seeding of rape. Experiments at the Station and those conducted elsewhere have shown that this seeding-year dominance of Italian Rye Grass may have a very serious smothering effect on the other elements of the sward.[11] It is a risk that must therefore be guarded against by the only practical method of dealing with this extraordinarily valuable, and but little understood, grass, namely, heavy, well regulated and intermittent grazing.

(2) *Cocksfoot (Spring Field only)*. The effect of the various treatments on this grass has been quite as striking as in the case of Italian Rye Grass. On Plots 5 and 6 (late " put up ") the percentage contribution of Cocksfoot has materially increased and the actual weight of produce per acre has also tended to increase. Notes taken on the plots suggest that whereas the heights of flowering panicles of Cocksfoot were conspicuously less on Plots 5 and 6 than on the earlier " put up " plots, yet the plants were more leafy and relatively bulkier. These observations are in complete agreement with the analytical data as given in the Tables. The counts of plants on the ground do not show large differences, but there are indications that strenuous competition with Italian Rye Grass and also late grazing

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10 For chemical evidence relative to the quality of the hay, see paper by Fagan and Evans, immediately following (see p. 134).

11 See Stapledon, R. G., and Jones, Rhoda. " Seeds Mixtures for Temporary Grass." This Journal, Volume I, 1925, p. 60 (see particularly pp. 91—92), and, Anonymous. " Notes from Craibstone: Mixtures for One Year's Hay." *Scottish Jour. Agriculture*, Vol. VIII, No. 2, p. 211.

both tend to decrease the total population of Cocksfoot plants in the sward. It is, however, difficult to explain why the yield of produce from Cocksfoot should be greater on the extreme plots (1 and 6) than on the intermediate plots.[12]

The practical interest of the data as applied to Cocksfoot is, however, that although this grass is not able to hold its own in competition with Italian Rye Grass in the hay—if the Italian Rye Grass is grazed off in the spring, then Cocksfoot is able to compete successfully with the weakened Rye Grass plants, and to contribute largely to the hay.

(3) *Tall Oat Grass (Spring Field only)*. There was not a very successful take from this species on the area under investigation, but the data are none the less informing in certain directions. Tall Oat is a grass which begins growth decidedly early in the season and is at that period extremely palatable; furthermore, it is found to be very adversely affected by heavy grazing when it is first coming into active growth.

The data indicate that Tall Oat is able to withstand competition with the other elements (including Italian Rye Grass) in the herbage, but that its amount is very rapidly decreased by grazing in the spring. It has been April grazing which has had the maximum effect on this species, and this would seem to be in accordance with expectations, for Tall Oat Grass makes little or no growth during the period November-early-middle-March.

(4) *Tall Fescue (Spring Field only)*. This grass has been observed as being of relatively low palatability[13] and although it makes early spring growth and is then more palatable than at any other time, yet it is not likely that Tall Fescue would be grazed to any appreciable extent on the plots, in view of the fact that Italian Rye Grass and Tall Oat[14] were present in the herbage and the former in relatively large amount. The tables bear out these suggestions and show that Tall Fescue does not appear to suffer from spring grazing, and when properly established it is apparently able to

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12 It has, however, been noted by Stapledon and Jones (*loc. cit*) that the greatest yield from any particular species is not necessarily given by the plots on which the species in question is represented by the greatest number of plants. Thus probably in the case of a particular mixture sown on a particular habitat the contribution of each species to the bulk of the produce will in the last resort wholly be determined by the relation which the number of plants of that species actually present bears to the optimum number necessary for a maximum contribution.

13 Davies, W. "The Relative Palatability of Pasture Plants." *Journ. Min. Agr.*, Vol. XXXII, No. 2, May, 1925.

14 Both species altogether more palatable at all times than Tall Fescue.

compete successfully with other species in the hay. The amount present in the hay was, however, in no case sufficient to give final evidence on the latter point.

(5) *Red Clover.* Past experiments conducted at the Station on pure plots of Red Clover have shown that this plant does not hold the ground so long under pasture conditions as when treated as hay.[15] At first sight the evidence from the Spring Field (Tables I and III) seems to suggest that the opposite has been the case in the present trials, for the productivity of Red Clover has been rather more on the later-grazed plots than on the early " put up." The explanation of this is, however, to be found in the fact that there are two major factors to be taken into consideration; firstly, the effect of a decrease in the extent of the competition from the Italian Rye Grass, and secondly, the effect of the differential grazing on the various species. In the case of Plots 1 to 3, Red Clover has been subject to a keen inter-specific competition, whereas in Plots 5 and 6 there was a minimum of competitive inter-action in the hay, but there has been a certain intensity of grazing at a critical stage in the seasonal growth of the plants. The data suggest that competition has had a more marked effect in decreasing the yield of Red Clover than has April grazing. It must, however, be recognised that Red Clovers, and especially the extra late flowering strains, make little growth under Welsh conditions until April is well advanced. Hence, in the present trial the Montgomery Red was not so heavily grazed as would have been expected merely judging by the high palatability of the plant and especially since Italian Rye Grass and to a more limited extent Cocksfoot were available in a more advanced stage of growth as well as being more easily accessible to the grazing animal.

The evidence from the Lane Field (Table A) is entirely in keeping with the above conclusions, for on that field, where grazing was continued during a period much more critical to the late Red Clover (up to May 12th) the yield of Clover from the February " put up " plot has been more than double that of the May 12th plot.

(6) *White Clover.* White Clover is usually regarded to be essentially a pasture plant, being able to withstand heavy and continual grazing, but being hampered by the competitive interaction of the other plants under hay conditions. Table I indicates that this has been the case on the Spring Field, the yield from White Clover having increased about four-fold on the average of Plots 5 and 6,

15 See Williams, R. D. " The Productivity of Different Strains and Nationalities of Red Clover under Hay and Pasture Conditions." *Welsh Plant Breeding Station, Bulletin,* Series H, No. 3.

as compared with the average of Plots 1 and 2. The evidence from the Lane Field also shows the hampering effect of Italian Rye Grass, but here the grazing far into May has not unnaturally shown a slight effect on the subsequent productivity of the White Clover.

(7) *Miscellaneous plants.* This group has included such plants as Red Fescue, Bent (*Agrostis*), Yorkshire Fog, and Sweet Vernal Grass, together with various dicotyledonous herbs. In the case of a group of plants such as this, each species having its own specific degree of growth, of palatability and of power to withstand competition from other plants, the total weed flora might be expected to remain relatively stable, despite the conditions super-imposed. From the data presented as well as from previous experience there is, however, little room for doubt that the total weed content tends to increase in inverse proportion to the intensity of competition from sown plants.

(*c*) COMPARISON OF THE INDIGENOUS WITH THE COMMERCIAL MIXTURE (Spring Field only).

Certain points of interest emerge from a study of the air dry hay weights of the indigenous and commercial representatives of the individual species (see Table I).

The two strains of Cocksfoot are in marked contrast from the point of view of their capacity for the production of early spring grazing. Indigenous Cocksfoot, a strain selected at the Station largely because of its potential value as a pasture plant, has significantly increased its total production in Plots 5 and 6 (late "put up") as compared to Plots 1, 2 and 3 (early "put up"). It has not been so adversely affected by April grazing as by the long continued competition with Italian Rye Grass. This may not seem to be in accord with the usual view that Cocksfoot is essentially a "hay" plant, rather than a "pasture" plant; the explanation would, however, seem to be that indigenous Cocksfoot, being later to start growth than the commercial strain, was not grazed to any great extent during April. In addition to this, the commercial strain, being of more erect habit, was more accessible as well as slightly more palatable in the April grazing period. Commercial Cocksfoot has thus not increased its productivity on Plots 5 and 6 relative to Plots 1 and 2, indicating that whereas on the early "put up" plots its total yield was diminished, due to the smothering effects of the Italian Rye Grass, on the late "put up" plots the yield was lowered to a similar degree by the April grazing.

A comparison of the data for the two strains of Tall Oat Grass is also of interest. The indigenous strain is later to begin growth in the spring than the commercial strains and again is less erect in its habit. The result of this diffeience in spring growth has been that the indigenous lot was less adversely affected by grazing during April. There are indications, too, that the grazing during April in 1924 on Plot 2 had already so adversely affected the commercial strain that the plants failed to recover even in the first harvest year.

The data from Montgomery extra late flowering Red Clover in the indigenous mixture, and from the Chilian early flowering strain in the commercial mixture, are significant and show that under both hay and pasture conditions the early Red Clover was to all intents and purposes out of the field after the first harvest year. Montgomery Red Clover even in the second harvest was contributing nearly one-seventh of the total bulk of hay, whilst the yield of Chilian Red was negligible.

The figures in Table I show considerably more White Clover on the area sown with Wild White even though hay analysis never does justice to the yield of this plant, especially so to the low growing and prostrate wild strain. Apart from this fact the comparison is rather biased in favour of the commercial strain inasmuch as a great deal of Wild White has made a voluntary (and unsown) appearance in the commercial plot.

Summary and General Conclusions.

(1) The trials dealt with in this paper have been essentially of a preliminary nature, and it is to be emphasised that they have not been conducted on properly replicated plots or on leys sown with mixtures specially designed for investigating the problems at issue. The evidence obtained is, however, of such fundamental importance in relation to the whole problem of seeds mixtures, and is so suggestive from the point of view of the directions in which further study should be developed, that it has seemed desirable to accede to the requests of a number of persons who have seen the plots and therefore to discuss such results as are already available.

Plans are now under consideration for the study of the whole matter in much greater detail, and a large series of special plots will be set up next spring.

(2) One point of considerable interest in relation to the development of grassland research as a whole has been the evidence afforded by the present trials of the value of investigating herbage problems by resort to subjecting single plants or small plots to a regulated system of "pasture cuts."

In the case of the present trials the "cutting" has been effected by the grazing animal (sheep) under absolutely normal farm conditions, but the results obtained have been on all fours with the teaching of the evidence built up at the Station during the past four years—data towards the collection of which resort had been made not to the grazing animal but to the shears and garden mowing machine.

(3) It is then the outstanding implication of the results under review rather than the detailed evidence that at present needs chiefly to be emphasised.

It is obvious if our grassland problems are to be approached in a true spirit of research that the profound influence exercised by the grazing animal—the biotic factor of the ecologist[16]—must be taken into consideration in relation to the interpretation put upon all the results that are recorded in connection with any set of grassland trials. It is perhaps extraordinary that this ever operative factor has been so generally overlooked, and it is the more to be regretted because it is the least constant of all the factors determining the characteristics of both artificial and permanent grass. Frequently the scheme of manuring adopted on grassland over whole districts is extraordinarily uniform, but no two farmers manage their grazing animals in quite the same way. Indeed, no two fields on the same farm can ever be uniformly subjected to precisely the same intensity of grazing week by week throughout the whole season. Thus, if we compare hay yields obtained at one experimental centre with those obtained at another, although the soil types may be remarkably similar and the manurial dressings may have been absolutely similar, it is quite certain that the intensity of grazing to which the fields have been respectively subjected before having been "put up" for hay will have been vastly different. Consequently, our results are likely to be influenced by a dominating or master factor which is never even taken into consideration, and differences which are perhaps entirely or primarily due to the biotic factor may erroneously be attributed to almost negligible differences connected with soil, aspect, height above sea level and the like, all of which will probably have been recorded with scrupulous care.

From a research point of view the matter is even more complicated in connection with a large series of plots on one and the same field. Here the plots are certain to be differentially grazed—such is the

16 See, for instance, Farrow, E. Pickworth. "Plant Life on East Anglian Heaths." Camb. Univ. Press, 1925. See also review of this book on p. 248 of this volume of the Journal.

grazing animal's reaction to subtle shades of relative palatability—and thus, no matter whether it be seeds mixtures or applications of manures that are under test, all the plots will have been subjected to a differential treatment over and above that which the experimentalist set out to test—this, since largely unsuspected, he frequently ignores!

The necessity for concentrating attention on the search for unsuspected disturbing factors in connection with any line of research will be admitted on all hands, and this is doubly essential when we are dealing with the interplay of complex and complex, such as our grassland in relation to human and other environmental influences exhibit. Three practical suggestions can be made with a view to discounting to some extent the uneven and frequently uncontrollable effect of the grazing animal. In the first place, for critical research purposes it may well be that the shears or mowing machine are a better and more exact means of effecting depasturage than the animal. In the second place, in connection with all trials where the results are presented in terms of hay yield, it is undoubtedly as, or more, important to record the date at which the plots were " put up " to hay, as to particularize the date upon which they were cut. In the third place, when hay results are in view, it is probably as important to make a botanical analysis of the herbage at the time, or shortly after, the plots are " put up " to hay, as to make separations on the hay itself—or rather the two analyses should be regarded as equally necessary and mutually inter-dependent.

(4) The detailed evidence obtained from the trials under review would seem to permit of the following conclusions—conclusions, however, which, pending confirmation from more exhaustive investigations, should be regarded as tentative:—

(*a*) It appears to be possible under a carefully executed scheme of spring grazing to restrict the amount of Italian Rye Grass in the hay and thus to minimise its competitive effect on the slower growing elements in the herbage.

Heavy grazing in April has a greater depressing effect on the yield of those species or strains that make early growth than on such species or strains as Montgomery Red Clover, Crested Dogstail, Wild White Clover, and to some extent Cocksfoot, especially the later indigenous strains, which start active growth considerably later in the spring.

(*b*) When grazing is continued far into May, the effect becomes greatly exaggerated, and then even the late species and strains will

suffer considerably, but not to the same relative extent as the early species and strains.

(*c*) The data so far available suggest even in the case of long duration leys that where first and second year swards have to be overstocked and grazed over-long in the spring, as is often the case on Welsh hill farms, then inclusion of Italian Rye Grass in the mixtures may in fact act as a protective measure against the too heavy grazing of the other elements in the herbage. Italian Rye Grass makes early spring growth, and hence by the month of April is more succulent than most species and is consequently correspondingly more palatable to stock, and is therefore more heavily grazed.

(*d*) April grazing has caused an increased yield in the hay of the slow growing species, indicating that whereas vigour is no doubt retarded by such treatment, yet the suppression of growth resulting from the presence of a large proportion of Italian Rye Grass in the hay on plots earlier " put up " has had an even more marked effect on the yielding ability of these late species.

The weed flora as a whole is affected in a similar manner, consequently an increase of weeds is found to be proportional to the decrease in competitive interaction.

(*e*) Comparing the two mixtures, the indigenous grasses and clovers are even in their second year out-yielding their commercial counterparts. Indigenous Cocksfoot is markedly superior to the commercial strain, whilst a comparison of the yields of Montgomery extra Late Flowering and of Chilian Broad Red Clover is overwhelmingly in favour of the former strain.

(*f*) The value and correct use of the extra late strains, such as Montgomery Red Clover, Wild White Clover, and selected indigenous strains of Cocksfoot and other grasses, will have to be considered in a new light if it will be found possible (as now seems highly probable)—by sowing these with relatively large amounts of Italian Rye Grass, and possibly with certain other early species and (or) with their own early counterpart strains—to provide for relatively abundant April grazing, and none the less from the same ley to provide for a comparatively heavy, albeit late " put up " and late cut, crop of predominantly herby hay.

In conclusion we would express our thanks to Mr. W. E. J. Milton, N.D.A., for valuable assistance in connection with the conduct of the trials, and to Mr. I. G. Lewis and Mr. J. L. Rees, two students in the Department of Agricultural Botany, for assistance with the various botanical analyses.

THE INFLUENCE OF THE DATE OF ENCLOSING FIELDS FOR HAY UPON THE YIELD AND CHEMICAL COMPOSITION OF THE CROP.

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The usual farm practice over a large area in Wales is to winter the mountain sheep in the lowlands where they are given the general run of the fields. The time of removing the sheep back from the lowlands to the hills varies in different districts from the first week in April to the first week in May, with the result that the time of enclosing fields for hay is often delayed until comparatively late. Further, when bulk of hay is a consideration, the harvest is postponed until late in the season, with the risk under our climatic conditions that when harvested the hay will be of poor quality. In a normal year a field that is enclosed in April produces a fairly satisfactory crop, but if the summer is dry it is often short and is therefore generally allowed to become over-ripe before cutting.

With the object of obtaining additional information as to the best time to put up fields for hay, the following experiments were conducted at the Welsh Plant Breeding Station, Aberystwyth, in season 1922-23:—

(i) On a temporary ley with a simple seed mixture in its first harvest year (Station No. E. 30. Part I).

(ii) On a permanent meadow (Station No. E. 30. Part III).

The present paper deals more particularly with the influence date of enclosing had on the chemical composition of the hay. The effect on the yield has already been reported upon in a Station publication (Series H. No. 3, Season 1920-23), A brief summary of this is given below.

Season 1922-23.

The 1923 hay crop generally was well above the average. The take of seeds in 1922 was good, and the plant in the spring, owing to the open winter, was thick and strong. The meadows, compared with the seeds, appeared to suffer more from the cold weather of the late spring, but with the warm weather in May these quickly recovered. The harvesting of the crop, especially in the later

districts, was a most difficult operation, and those who were not fortunate enough to secure their crops in the first fortnight of July found their hay making, owing to the continuous rain that followed, a very protracted operation. The hay from these experimental plots was harvested under excellent conditions.

(i) Temporary Ley.

The soil of the Brick Field, where the experiment was carried out, is a light loam formed from the Aberystwyth Grits, and apart from the fact that it is a little deeper it is typical of those in the district. The field since 1904 has been under rotation. In 1917 it was seeded down and hay crops taken from it in 1918 and 1919 respectively. Subsequent to being broken up it has carried an Oat crop in 1920, Wheat in 1921, to which 5 cwt. of Basic Slag was applied, and in May, 1922, the following seed mixture without a nurse crop was sown:—

10.5 lbs. Perennial Rye Grass.
8.1 lbs. Cocksfoot.
4.7 lbs. Timothy.
4.2 lbs. Montgomeryshire Red Clover.

The experiment consisted of three main plots made up of three sub-plots 1/400 of an acre in area. Each plot was thus in triplicate. All the plots were grazed by sheep up to December 30th, 1922, when the three sub-plots forming the series in Plot I, namely a/1, b/1 and c/1, were enclosed for hay which was harvested on July 17th, 1923.

The three sub-plots forming the series in Plot II, namely a/2, b/2 and c/2, were cut with a lawn-mower on February 28th, 1923, the produce weighed, and the hay from this series cut, and harvested, on July 17th, 1923. The remaining three sub-plots, a/3, b/3 and c/3, forming the series in Plot III, were cut with a lawn-mower on April 27th, 1923, the produce weighed, and the hay harvested on July 17th, 1923.

It will thus be noted that the hay from all the plots was cut on the same day, that is to say, the plots "put up" late were not given as long a growing period in which to produce a crop as were those put up earlier.

Influence on Yield.

As previously mentioned, the influence that the date of enclosing had on the yield of hay has already been published. This briefly summarised, taking the yield of the plot enclosed in December as standard, was as follows:—

The yield of the plot enclosed in February showed a decrease of 3 per cent. in hay, but on adding the produce grown on this plot between December and February to that of the hay both plots gave similar results.

The plot enclosed in April showed a loss in yield of 21 per cent., and when produce from December to April was added to that of the hay there was still a loss of 4 per cent. as compared with the plot enclosed in December.

Influence on Chemical Composition.

Table I gives the chemical composition of the dry matter of the hay from the three sub-plots forming the series Plots I, II and III respectively, as well as the average composition of the dry matter of the hay from these plots.

Examination of Table I shows the agreement in chemical composition of the dry matter of the hay from the different sub-plots forming a series to be quite satisfactory. The widest variation is seen to be in the fibre, and though the accumulated errors of the determinations enter into the figure for soluble carbohydrates, this could not be called excessive. On comparing the average percentage composition of the dry matter of the hay from the plots enclosed in December, February and April, the superiority of the hay from the April-enclosed plot is quite pronounced. Thus the percentage of protein is appreciably higher and the fibre lower than in either of the other two. Further, as the date of enclosing is postponed, the percentage of protein is seen to gradually increase and that of the fibre to decrease. A comparison of the average percentage composition of the hay from the three main plots in ether extract, fibre and protein indicates a younger growth as the date of enclosing is delayed.

The results given in Table Ia were obtained from an experiment designed to give data for comparing the behaviour of a simple seed mixture kept for hay, with the same for grazing. They are included in this paper because the experiment was conducted in the Brick Field and in all details of management is comparable with the plots enclosed in December described in the previous experiment. The seed mixture sown in this experiment, however, differs somewhat from that in the first, for it contains a little more Perennial Rye Grass, no Timothy, and late flowering English Red Clover was substituted for Montgomeryshire Red Clover. It affords, therefore, a comparison of two hays produced from two different seed mixtures under otherwise identical conditions.

TABLE I.

Showing the influence that the date of enclosing fields has on the chemical composition of the dry matter of hay from temporary grass.

Sub-plots.	Ether Extract.	Crude Protein.	True Protein.	Fibre.	Ash.	Soluble Carbohydrates	Silica (SiO_2).	Phosphoric Acid (P_2O_5).	Calcium Oxide (CaO).	Oxide of Iron (Fe_2O_3)	Chlorine (Cl).	Nitrogen.
PLOT I. ENCLOSED IN DECEMBER, 1922.												
a/1	1.00	8.31	7.25	35.06	6.49	49.14	1.47	0.39	1.30	0.029	0.334	1.33
b/1	2.05	9.54	8.36	37.40	6.37	43.67	1.31	0.40	1.51	0.023	0.327	1.52
c/1	2.20	8.63	7.75	35.65	7.34	45.69	0.97	0.34	1.46	0.024	0.303	1.38
AVERAGE ...	1.75	8.83	7.78	36.04	6.76	46.16	1.25	0.38	1.42	0.025	0.321	1.41
PLOT II. ENCLOSED IN FEBRUARY, 1923.												
a/2	2.05	10.12	9.00	31.95	7.38	48.50	1.60	0.55	1.55	0.025	0.363	1.62
b/2	1.75	10.50	9.18	30.85	7.43	49.47	1.38	0.44	1.59	0.023	0.363	1.68
c/2	1.60	11.38	8.93	34.75	7.83	44.44	1.58	0.43	1.71	0.028	0.400	1.82
AVERAGE ...	1.80	10.66	9.03	32.52	7.54	47.48	1.52	0.47	1.62	0.025	0.375	1.70
PLOT III. ENCLOSED IN APRIL, 1923.												
a/3	3.05	12.00	10.87	30.50	10.03	44.42	1.03	0.35	1.91	0.017	0.458	1.92
b/3	1.45	11.71	10.37	30.05	7.51	49.28	1.08	0.38	1.78	0.023	0.386	1.87
c/3	2.35	12.31	11.31	28.30	7.69	49.35	1.07	0.39	1.74	0.031	0.431	1.96
AVERAGE ...	2.28	12.01	10.85	29.61	8.41	47.69	1.06	0.37	1.81	0.024	0.425	1.92

TABLE Ia.

Showing the chemical composition of dry matter of hay from temporary ley.

PLOT I.

ENCLOSED IN DECEMBER, 1922.

Sub-plots.	Ether Extract.	Crude Protein.	True Protein.	Fibre.	Ash.	Soluble Carbohydrates	Silica (SiO_2).	Phosphoric Acid (P_2O_5).	Calcium Oxide (CaO).	Oxide of Iron (Fe_2O_3)	Chlorine (Cl).	Nitrogen.
a/1	1.90	9.44	8.63	34.95	6.09	47.62	1.08	0.44	1.63	0.040	0.369	1.51
b/1	2.05	9.20	8.50	36.50	7.58	44.67	0.93	0.38	1.54	0.045	0.359	1.48
c/1	1.70	10.05	9.20	35.90	6.57	45.78	0.97	0.43	1.69	0.043	0.307	1.60
AVERAGE ...	1.88	9.56	8.78	35.78	6.75	46.02	0.99	0.42	1.62	0.043	0.345	1.53

The seed mixture used in this case was:—

12 lb. Perennial Rye Grass.
8 lb. Cocksfoot.
4.2 lb. English late flowering Red Clover.

Table Ia gives the chemical composition of the dry matter of the hay from the three sub-plots, as well as the average composition of the dry matter of the hay from these plots.

A comparison of the average composition of the dry matter of the hay in Table Ia with that for the December enclosed plots given in Table I shows the former to be distinctly superior in chemical composition.

This, in view of the fact that the second seed mixture contains a higher proportion of Clover, no Timothy, and an increased amount of Perennial Rye Grass, is of interest. The relative increase of Clover to grass seed in the mixture would lead one to expect a higher protein content in the hay in Table Ia, as compared with the hay from the December enclosed plots in Table I.

The difference, however, is not as great as would be expected. This is probably to be accounted for by the fact that owing to the presence of Timothy and Montgomeryshire Red Clover, both late maturing plants, in the first seed mixture, the produce when harvested would have been decidedly more leafy than that of the mixture containing earlier maturing species and strains. This greater leafiness no doubt counterbalanced the higher proportion of clover in the second mixture in so far as the relative protein content of the hay taken from each plot was concerned.

(ii) Permanent Meadow.

The Quarry Field in which this experiment was conducted is a light loam formed from the Aberystwyth Grits. The field for some years prior to 1917 had been used as a pasture from which a hay crop was taken in 1912; since 1917, however, it has been used as a meadow.

The experiment consisted of three main plots 1/100 of an acre in area, each plot being sub-divided into four sub-plots of 1/400 of an acre. In December, 1922, the whole field was grazed by sheep, and on the 26th December, 1922, cut with a hay reaper to remove fog, all the plots being enclosed at this date. Plot I, made up of the series of sub-plots a/1, b/1, c/1 and d/1, was then allowed to run to hay, which was harvested on July 18th, 1923.

Plot II, made up of the series of sub-plots a/2, b/2, c/2 and d/2, was cut with a lawn-mower on March 31st, 1923, the produce between

December and this date weighed, and the hay harvested on July 18th, 1923.

Plot III was cut with a lawn-mower on April 26th, 1923, the produce weighed, and the hay harvested on July 18th, 1923.

Influence on Yield.

Taking, as in the previous experiment, the plot enclosed in December as standard, the plot enclosed in March showed a loss of 5 per cent., which was reduced to 1 per cent. when the produce of the plots from December to March was added to that of the hay. In the case of the plot enclosed in April there was a loss of 16 per cent. on the hay crop alone, and when the produce grown between December and April was added to that of the hay this still remained at 7 per cent.

Influence on Composition.

Table II gives the chemical composition of the hay from each of the four sub-plots forming the series Plot I, II and III respectively, as well as the average composition of the hay from these plots.

Examination of Table II shows that in the case of the permanent meadow the difference in the average percentage composition of the dry matter of the hay from the December enclosed plot and those enclosed later is not as great as that found in the temporary ley. The December enclosed plot is certainly a little poorer in protein and contains on an average a higher percentage of fibre than the later enclosed plots, but the difference between the March and April enclosed plots is negligible. There are several factors to account for this, the chief of which probably are that in a permanent meadow the soil conditions are not so favourable for rapid growth as they are in a temporary ley.

Again, in a permanent meadow that has been down for a number of years and under our local conditions, a large percentage of the grasses would be Agrostis, which is comparatively late in growth. This is confirmed by a botanical analysis of these plots, carried out by the staff of the Plant Breeding Station, which showed that 42 per cent. of the herbage consisted of Agrostis.

Further, the ability to recover and start growth after cutting is probably greater in those grasses forming a temporary ley than in those found in a permanent meadow.

The question of the management and treatment of seeds hay is one on which a variety of opinions are held by practical men. Some maintain that in addition to reducing the bulk of hay in the first harvest year the grazing of the seeds during winter and spring has a

TABLE II.

Showing the influence that the date of enclosing has on the chemical composition of the dry matter of meadow hay.

PLOT I.

ENCLOSED IN DECEMBER.

Sub-plots.	Ether Extract.	Crude Protein.	True Protein.	Fibre.	Ash.	Soluble Carbohydrates.	Silica (SiO_2).	Phosphoric Acid (P_2O_5).	Calcium Oxide (CaO).	Oxide of Iron (Fe_2O_3)	Chlorine (Cl).	Nitrogen.
a/1	1.55	7.19	6.13	35.05	6.21	50.00	1.31	0.43	0.78	0.017	0.553	1.15
b/1	2.55	8.63	7.00	36.35	6.16	45.91	1.28	0.54	0.62	0.017	0.573	1.38
c/1	1.65	9.06	7.75	33.85	6.20	49.24	1.16	0.41	0.72	0.015	0.563	1.44
d/1	2.70	8.88	7.74	33.20	7.06	48.16	0.96	0.57	0.71	0.019	0.573	1.42
AVERAGE ...	2.11	8.44	7.15	34.66	6.41	48.30	1.18	0.49	0.71	0.017	0.565	1.35

PLOT II.

ENCLOSED IN MARCH.

Sub-plots.	Ether Extract.	Crude Protein.	True Protein.	Fibre.	Ash.	Soluble Carbohydrates.	Silica (SiO_2).	Phosphoric Acid (P_2O_5).	Calcium Oxide (CaO).	Oxide of Iron (Fe_2O_3)	Chlorine (Cl).	Nitrogen.
a/2	2.20	9.56	7.50	34.75	6.34	47.15	1.60	0.67	0.95	0.032	0.616	1.53
b/2	2.60	9.81	7.69	31.25	7.00	49.34	1.86	0.58	0.75	0.032	0.637	1.57
c/2	2.95	9.19	8.18	35.45	6.76	45.65	3.76	0.44	0.89	0.037	0.637	1.47
d/2	3.30	10.00	9.19	32.60	6.38	47.72	2.07	0.44	0.98	0.032	0.616	1.60
AVERAGE ..	2.76	9.64	8.14	33.51	6.62	47.47	2.32	0.53	0.89	0.033	0.626	1.54

PLOT III.

ENCLOSED IN APRIL.

Sub-plots.	Ether Extract.	Crude Protein.	True Protein.	Fibre.	Ash.	Soluble Carbohydrates.	Silica (SiO_2).	Phosphoric Acid (P_2O_5).	Calcium Oxide (CaO).	Oxide of Iron (Fe_2O_3)	Chlorine (Cl).	Nitrogen.
a/3	2.95	9.19	8.06	34.00	6.86	47.00	1.47	0.51	1.00	0.030	0.784	1.47
b/3	2.85	9.56	8.93	33.60	6.77	47.22	1.47	0.48	1.34	0.017	0.784	1.53
c/3	2.00	10.62	7.99	32.55	6.24	49.59	1.22	0.54	1.25	0.023	0.720	1.70
d/3	3.10	8.77	7.25	32.65	6.22	49.26	1.34	0.55	1.32	0.023	0.720	1.40
AVERAGE ...	2.73	9.54	8.06	33.20	6.52	48.01	1.37	0.52	1.25	0.023	0.752	1.52

deleterious effect on the succeeding hay crops and pastures. Excessive grazing in the spring undoubtedly reacts adversely on the subsequent productivity and persistency of many of the grasses and clovers. On the other hand, early enclosing of fields for hay often results in the crop being laid, while valuable grazing is lost at a time when most wanted. When winter keep is short there is no option under prevailing systems of management but to turn the live stock on to the "seeds," especially during the lambing season. Indeed, the custom in some parts is to reserve the seeds for this particular purpose, and under these circumstances the fields may not be enclosed until the end of April or beginning of May.

With regard to the permanent meadows the general custom is to graze these until late spring, for since they are harvested last they have a longer growing period, continuing growth until late in the season.

The influence of the above factors on the chemical composition of the hay obtained from temporary leys and permanent meadows is to a large extent shown by the results under consideration.

It should, however, be borne in mind that the above experimental plots were cut with a lawn-mower and not continually grazed by sheep in the early spring as is usually the case in farm practice. In addition, all the plots, irrespective of date of enclosure, were cut on the same date.

Comment on the percentage of the different mineral constituents found in the dry matter of the hays has been deferred in the belief that the comparison and discussion of these would be facilitated by taking all together.

Reference to Table I shows that the date of enclosing the plots has a considerable influence on the mineral constituents of the seed hay, delay in enclosing being followed by an appreciable increase, especially in the case of lime and chlorine. The phosphoric acid and iron on the other hand do not seem to be greatly affected, the ratio of phosphoric acid to lime, however, is decreased as date of enclosing the plots is put off.

The composition of the meadow hay is similarly affected to that of the seed hay. Thus there is a progressive increase in lime and chlorine, but in the case of iron the increase shown in the March enclosed plot is not maintained in the one enclosed in April. The percentage of phosphoric acid, as was the case with the seed hay, is not affected to any great extent.

The reasons already put forward to explain the differences in the composition of the seed hay shown in the December enclosed plots

(Tables I and Ia) are emphasised by a comparison of the mineral content of both. Thus the differences in the percentage of Silica, phosphoric acid and lime, though small, are all in the direction that would be expected as the result of the presence of a higher percentage of clover in the hay of Table Ia. A comparison of Tables I and II shows that the chief difference between seed hay and meadow hay is to be seen in their lime and chlorine content. The seed hay is markedly superior in lime, while the meadow hay is much richer in chlorine.

Briefly summarised, the results from the chemical analysis of the experiments under review are as follows:—

1. The time of enclosing fields for hay appears from these results to have a greater influence on the chemical composition of the seed hay than on the hay from permanent meadows.

2. The seed hay from the later enclosed plot is superior in chemical composition to that obtained from the earlier enclosed plots, and when yield of grazing and hay is taken into consideration the February enclosed plot gives the best results.

3. Hay and grazing of the best quality are given by grasses with a high percentage of leaf to stem.[1] A comparison of Table I (the December enclosed plot) with the results shown in Table Ia suggests that from the point of view of chemical composition of the produce alone a low ratio of clover to grass seeds in a mixture might to some extent be counterbalanced by the inclusion of the more leafy grasses in the mixture, and by cutting the crop before the grasses have fully matured.

4. Fields enclosed for hay later than early March, when compared with those enclosed earlier, suffer from a considerable reduction in bulk, and if to ensure bulk the hay is harvested late the quality suffers and is accompanied by a considerable reduction in aftermath.

PROPOSALS FOR A SOIL SURVEY OF WALES.

By G. W. Robinson, M.A.,

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Plans are now being made for the extension to the rest of Wales of the soil survey work which has been carried out during the past thirteen years in the Bangor and Aberystwyth provinces. The

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[1] See Fagan and Evans. Table I, page 114 of this Journal.

initiative came from the Ministry of Agriculture and Fisheries, who have made a grant to enable the work to be carried to completion. The survey is under the general direction of the writer, and Messrs. J. O. Jones, M.Sc., and D. O. Hughes, B.Sc., have been appointed to assist in the necessary field and laboratory work. For the successful prosecution of this project it will be necessary to call for the interest and co-operation of many workers in addition to those primarily responsible for the work. The aim of the present article is to place before readers of this Journal some account of what has been done in the past and to discuss the character of the work which is proposed for the future.

The first systematic soil survey carried out in this country was that of Kent, Surrey and Sussex by Hall and Russell. The underlying principle of their survey is that, in the area surveyed by them, the character of the soil is closely governed by the geology. Each geological formation is thus reflected in a corresponding soil type, and the geological map can serve also as a soil map. If this close correlation can be assumed, then the work of the soil surveyor simply consists in the collection of a sufficient number of soil samples from the outcrop of each formation to characterise the soil type, allowance being made for lithological changes within the same geological formation.

The area chosen by Hall and Russell was well suited to this type of soil survey, being fairly uniform in climate and free from that bane of the soil surveyor, glacial drift. Where similar conditions prevail, it is to be expected that a purely geological classification will suffice to define the principal soil types. A considerable body of soil survey work has been carried out along the lines of Hall and Russell's work, notably in East Anglia by the Cambridge School of Agriculture.

Where, however, there is a great diversity in surface and climatic conditions, and where the solid geology is largely obscured by glacial drifts, it is obvious that the correlation between soils and geology will be somewhat imperfect. This was found to be the case over a large part of Shropshire, where the present writer carried out a preliminary soil survey in 1910-12. Although a fairly good correlation between soil and geology was found in the areas free from drift, great difficulty was experienced in the extensive areas of that county where the solid geology is obscured by glacial drift. The difficulty was rendered more acute by the lack, at that time, of any formal drift maps of the area.

described as gravelly loams. They are generally of fair fertility, although this depends largely on altitude and aspect. Where the situation is favourable, as in the Llanerchymedd district of Anglesey, they carry pastures of excellent quality. Most of the silt loams are derived in situ from the underlying rock, or, more rarely, from purely local drift.

The local glacial drift which borders the mountain area of Carnarvonshire on the north and west gives rise to a series of soils which have been grouped together as the Carnarvon Stony Loams. Since the drift of this area is derived from a great variety of rocks, both igneous and sedimentary, there is a considerable variation in the texture and other properties of the associated soils, but they agree in being of a stony character, particularly near the mountain area. The substantial walls of glacial boulders which enclose the fields of the small upland farms of Carnarvonshire give an idea of the large proportions of stones and boulders which were originally present in these soils, and indicate the method by which they were reclaimed for cultivation. Some of the soil of this series—one can scarcely call it a type—are fairly heavy, as in the Aber district. Here the parent material is chiefly shale. In the western part of the area the soils are lighter, owing to the presence of igneous débris among the parent material. The fertility of the stony loams depends largely on situation, and one finds all gradations from the fertile lowlands bordering on the Lavan Sands to the poorer upland soils on the margin of cultivation.

In west Carnarvonshire there occur glacial soils of mixed origin, consisting partly of local material and partly of material brought from the north by the Irish Sea glacier. These are grouped together as a series to which the name West Carnarvon Light Loams has been given. Like the stony loams, they form a series rather than a type and pass into light sandy loams on the one hand and into heavy loams on the other.. They are much less stony than the stony loams and are of moderate fertility. If they were more accessible it is probable that they would be in a higher state of cultivation.

The Carboniferous Limestone and the Millstone Grit each give rise to a series of soils. Both may be sub-divided into a lowland and an upland facies respectively. They do not cover such large areas as the soil types described above, and have not as yet been studied so completely. The lithological variation in the Carboniferous Limestone is so great that one can scarcely expect uniformity in the derived soils. It is noteworthy that the upland Carboniferous Limestone soils are often deficient in lime owing to leaching from the surface layers.

In the eastern lowlands of North Wales, and also in west Carnarvonshire, one finds considerable areas of glacial sands. These are of variable fertility, but are sometimes in a fairly high state of cultivation. Heavy boulder clays are found in the Maelor district of Flintshire and in the Vale of Clwyd.

Amongst the other types of soil which have been recognised are blown sands, peats (including fen and upland peat), estuarine alluvia, and fluviatile alluvia. These types are generally well defined and easily delimited.

The soils of North Wales are generally characterised by their medium texture. Large areas of heavy clay, or light sands, apart from the coastal sands, are not encountered. The proportions of organic matter are generally high, and there is a marked tendency to deficiency in lime. In fact, it is exceptional to find calcium carbonate in typical North Wales soils. There is generally, however, a fair content of available non-carbonate calcium in cultivated soils.

The chief task up to the present has been the recognition of the principal soil types, and whilst a general idea has been obtained as to their distribution, no attempt has been made to map them formally in the field. A provisional soil map has been made for North Wales, but the boundaries are often conjectural.

The extension of the soil survey to Wales as a whole necessitates the recognition of soil types occurring in those parts of the country which have not hitherto been surveyed. The ultimate object is to secure, so far as possible, the representation of the different types of soil in map form, and to secure such a record that it will be possible, by reference to the soil maps and their accompanying memoirs, to ascertain the general character of the soil in any locality in Wales. This should facilitate the giving of advice on manuring and soil treatment, since it will be possible to group together certain areas as similar in soil, surface features, and climate. Could such a grouping be obtained the next step would be the location of permanent field experiments according to the principal types of grouped factors. For example, let us suppose that a type of grouped factors could be thus described: Palæozoic Silt Loams, rolling surface at 300-600 feet, rainfall 40-60 inches per annum. It is reasonable to suppose that the results of field experiments on such an agricultural type will be applicable wherever such a conjunction of soil type, surface, altitude and climate occurs.

Data as to surface and altitude can all be obtained from the Ordnance Survey maps. It may be necessary, however, to record

additional data as to the actual character of the surface, which cannot be found on the Ordnance Survey maps. Climatic data are fairly abundant and are constantly being added to, but they need supplementing in certain respects, notably in temperature observations. Our principal task is therefore the collection and mapping of data as to the soil. The data which have already been obtained in the soil work of the Aberystwyth and Bangor Colleges will form the foundation upon which future work will be built up.

Since a large part of the work of the soil surveyor consists in the interpretation of data obtained in field and laboratory, we shall venture to discuss briefly the problem of soil classification and mapping. The almost infinite variety of soils is familiar to every agriculturist. Their classification is rendered difficult by the basic fact that soils are not individuals, like plants and animals, but constitute a continuous covering over the earth's surface in which, although great differences occur, sharply defined boundaries are rarely seen. It is quite often the case that one type of soil shades into another by imperceptible degrees and one is constantly forced to consider large areas of soil as transition types and to fix purely arbitrary boundaries. Another difficulty is found in the extent to which soils have been altered by human interference, particularly in an old settled country, where the original characters of the soil have been almost obliterated.

A map is merely a convenient method of representing facts and the different colours and boundaries shown on it may have no objective existence but may be simply the interpretation of the collected data by the soil surveyor. If, in a certain region, soils cannot be separated into types with definite and unmistakable boundaries, then a map of such an area must either carry on it the data for every field or else some arbitrary standards must be adopted and boundaries laid down accordingly. For instance, if we are dealing with an area of boulder clay soils in which we can trace every gradation from heavy clay to sandy loams, these can only be differentiated on the basis of laboratory examination, and one is forced to adopt an arbitrary standard of classification such as the percentage of sand. The boundaries laid down by the aid of such artificial classification, though necessary and useful, will have no more objective existence than the meridian of Greenwich or the equator.

Now it is obvious that soils can be classified in many different ways. We may classify them according to their texture, organic matter content, and chemical composition, i.e., according to their

actual properties. Or we may adopt a genetic classification and divide them up according to their parent material as in the geological classification of Hall and Russell, or according to the climatic factors which have governed their formation, following the Russian school of pedologists. Or we may classify them on ecological lines according to the type of vegetation which they carry in their virgin state, a method which is claimed to give the summation of all the factors affecting plant growth in the uncultivated state. From the purely philosophical viewpoint a genetic classification is to be preferred, and doubtless if we knew enough about the mode of formation of soils and the natural factors influencing their properties a genetic classification would give us at the same time a practical classification, since the properties of the soil are the summation of all the factors concerned in their formation.

In the present state of our knowledge, and bearing in mind that the survey must serve a practical end, one is practically forced to use as the criteria of soil classification those properties which are of importance to the cultivator. From this point of view the principal properties to be considered are the texture of the soil and its relationship to the underlying strata of subsoil and parent material. Chemical composition, including organic matter and lime content, may also be taken into account, though, except in the case of chalk soils and peats, it is subsidiary to texture and profile from the point of view of the economic utilisation of the soil.

In the isolation and recognition of soil types one must proceed as experience dictates, and it should be realised that the problem of soil classification will differ in different regions. Although attempts are being made to construct soil maps of large areas, it is obvious that such maps can only show very broad distinctions. In a general soil map of Europe it would be impracticable to represent all the different soil types which could be differentiated on the basis of their actual properties. Probably for such a map it would be better to adopt a climatic classification, such as that of the Russian school, and divide up the area into climatic provinces with sub-divisions based on topography. An example of this type of map is the primary soil map of the United States of America, in which that country is divided up into provinces, each of which has certain features of climate and topography which enable it to be distinguished from other provinces. Within each province a number of soil types will be recognised. These, although important from the point of view of agriculture, cannot all be represented on the map of the whole country. Even in such a small country as Wales

it is doubtful if all the types of soil which could be distinguished could be conveniently shown on a single map. It may, however, be possible to distinguish certain provinces and to show the principal groups of soil types within each province.

Proceeding to the actual practical details of a soil survey, the first step will be to select certain convenient areas for survey. For this purpose it may be better to be guided by topography rather than by county boundaries. The valley of a considerable river and its tributaries would be a natural area for study. A preliminary reconnaissance will be made in order to obtain a general idea of the region. During this reconnaissance samples will be taken for laboratory examination. Wherever a sample is taken an examination of the soil profile will be made. From a consideration of the field and laboratory data it should be possible to recognise the principal soil types of the area under study. At this stage sufficient acquaintance will have been obtained with most of the types for the surveyor to be able to recognise them in the field. In other cases, where a set of soils forms a variable series rather than a type, it should at least be possible to recognise the principal phases of the series. Having determined on the standards for the different types, the actual mapping will then be undertaken. It is proposed to carry this out on the scale of six inches to the mile and the six-inch series of the Ordnance Survey will be used as the base maps on which the soil data will be inserted. The soil surveyor will take out each six-inch map in turn and traverse as far as possible all the roads and paths, making notes as to the character of the adjacent soils and other features of agricultural importance not already on the ordnance maps, as, for example, rocky ground, areas of bad drainage, or uncultivated slopes. It would be desirable, of course, that some data should be inserted for every field, but this may entail too slow a rate of progress. It should in any case be possible to mark down the principal features which, together with the soil properties, influence the agricultural characters of the area under survey.

If the soil types are sufficiently definite it should now be possible to delimit their boundaries. In some cases there may be difficulty and it may be necessary to take additional samples for laboratory examination. It will probably also be found that a certain number of additional types must be separated out. Some of the boundaries must, as has already been explained, be laid down arbitrarily. Where, in an area free from drift, a close correlation is found between the solid geology and the derived soil, the solid geological map will help in fixing boundaries.

The six-inch maps after the insertion of all the field data will, together with the accompanying laboratory data and other notes, constitute the actual survey, and, if the work has been efficiently executed, should embody all information relating to the natural conditions of soil and surface. The climatic data will of course be shown on separate maps, but in any description of the natural factors of a given locality, they must be considered along with the data shown on the six-inch soil maps.

The six-inch maps will constitute a permanent body of information but it is scarcely possible for these to be published, and it will be necessary to generalise the information contained in them and in the accompanying memoirs so as to obtain maps, probably on the scale of one inch to the mile, suitable for publication. For actual working use, however, the six-inch maps will give the most detailed information, and it is to be hoped that it may be possible to arrange that they shall be kept, when completed, as permanent archives, readily accessible to all who may wish to consult them. Many possibilities suggest themselves for the care and utilisation of the soil survey maps and memoirs, but the discussion of this, one of the least difficult aspects of the general problem, may be fittingly postponed until the documents in question shall have achieved a material existence.

EXPERIMENTS ON THE MANURING OF SWEDES IN ANGLESEY, CARNARVONSHIRE, DENBIGHSHIRE AND FLINTSHIRE, 1885—1924.

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A large number of field trials on the manuring of swedes has been carried out in North Wales since 1885, and it is felt that the collective results of these experiments must be of value not only to the farming community but also to those engaged in the planning of similar trials

in this area. Owing to soil variations, etc., the result of one trial carried out with single or duplicate plots is not reliable unless there is a large difference between, for instance, the effect of two manures or between the yielding capacity of the varieties under test. When the differences amount to, say, less than 10 per cent. it is only by having a large number of trials, or by having a large number of replications in the trial, that it is possible to say with certainty whether the difference is due to the manure or the variety or to accidental variation in the soil. The necessity of considering results collectively, or of laying down trials with a large number of replications, is felt more and more, because field work has already sifted out the useful from the useless manures under average conditions or the very heavy from the very light cropping variety, and the majority of present day problems involve differences which are not easily distinguishable from those due to accidental variations. For instance, while there is no doubt as to the necessity of a phosphatic manure for the swede crop, and while the result of a trial with a single or a duplicate plot could be relied on under most conditions to test this point, it would require a large number of such trials or an experiment with a large number of replications to decide as to whether 100 lb. of total phosphate in High Grade Slag is superior as a dressing for swedes to the same quantity in the form of Low Grade (High Solubility) Slag under certain conditions of soil and climate. While this point is under consideration advantage is taken of the opportunity of expressing the opinion that it is more useful to take one definite point such as this and to test it thoroughly by a trial with a large number of replicated plots than to lay down field trials containing five or six manures in single or duplicate plots; such trials only give definite information when carried out for a number of years.

Before the appointment of Agricultural Organisers experimental work in the four counties was carried out by the University College of North Wales, Bangor. Under present arrangements field work is carried out by the Organisers, working in conjunction with the Agricultural Department of the College, conferences being convened periodically with the object of securing uniformity in field trials; in this way the collective results have a value which could not be obtained if the experiments were not carried out according to a general scheme.

Area under Swedes and Turnips.

The area under these crops in the four counties is returned as

15,000 acres for 1924, being 3,900 less than in 1914. The total is made up as follows:—

	Area under Turnips and Swedes.		Total cattle in 1924.
	1924.	1914.	
Anglesey ...	3,900	4,800	52,400
Carnarvonshire ...	2,500	3,000	52,400
Denbighshire ...	6,200	7,700	75,200
Flintshire ...	2,400	3,400	43,400
	15,000	18,900	223,400

The climatic conditions of North Wales make it possible to grow heavy crops of roots, provided suitable manures are given. A consideration of the heavy expense of the root crop makes it evident that only heavy crops can make them worth while; the effect of manuring on the yield of this crop may be gathered from the fact that out of 223 applications of phosphatic manures in field trials 132 gave an increase of over five tons per acre, whilst sixty-seven of this number gave an increase of over ten tons per acre.

Weight of Manurial Dressings.

In recent years the weight of the particular manure under test in each plot has been such that the same quantity of total phosphate or of potash or of nitrogen was supplied per acre. In the earlier years under review the weights of manure applied were such as were considered to be average dressings in the district. In most trials the plots received a dressing of farmyard manure and a light dressing of potassic and nitrogenous manures, for instance, when phosphatic fertilizers were under test, so as to avoid the possibility of a supply of these becoming the limiting factor; similar precautions were taken in testing potassic and nitrogenous manures.

Number of Centres and Plots.

Trials were carried out at 127 centres in the area, the total number of plots weighed exceeding 700, and the results contain 640 comparisons of manured and unmanured plots.

Method of Stating Results.

The results are herein expressed as

(*a*) Weight of increase of crop caused by application.

(*b*) Percentage of increase of crop caused by application.

TABLE I. (Increase expressed as weight of crop increase per acre.)

Percentage number of Plots giving an increase of—

	10 *cwt.* or *less.*	11—20 *cwt.*	21—40 *cwt.*	41—60 *cwt.*	61—80 *cwt.*	81—100 *cwt.*	101—120 *cwt.*	121—140 *cwt.*	141—160 *cwt.*	161—180 *cwt.*	181—200 *cwt.*	201—220 *cwt.*	221—240 *cwt.*	*Above* 240 *cwt.*	*Total Number of Comparisons.*
Phosphatic Manures......	11.1	4.7	3.0	3.0	10.8	9.4	5.6	9.0	5.2	3.4	5.2	3.0	4.5	22.1	232
Potash Manures	34.0	9.3	18.8	9.3	12.0	6.0	6.0	2.6	0.7	1.3	..	..	..	..	150
Nitrogenous Manures	57.6	12.6	12.0	7.2	5.2	1.4	3.3	..	0.7	..	..	..	..	..	152
Farmyard Manure	..	..	3.7	3.7	11.1	3.7	3.7	3.7	3.7	7.4	3.7	7.4	3.7	44.5	27

TABLE II. (Increase expressed as percentage increase.)

Percentage number of Plots giving an increase of—

	10% or *less.*	11 *to* 20%	21 *to* 30%	31 *to* 40%	41 *to* 50%	51 *to* 60%	61 *to* 70%	71 *to* 80%	81 *to* 90%	91 *to* 100%	101 *to* 110%	111 *to* 120%	121 *to* 130%	131 *to* 140%	141 *to* 150%	151 *to* 160%	161 *to* 170%	171 *to* 180%	181 *to* 190%	191 *to* 200%	201 *to* 300%	301 *to* 400%	401 *to* 500%	501 *to* 600%	*Above* 600%
Phosphatic Manures......	20.0	12.3	8.6	8.6	3.4	4.3	4.7	3.0	3.0	3.0	1.3	1.7	2.6	2.1	1.7	0.9	2.6	0.9	0.4	2.6	3.4	2.1	1.3	2.1	3.4
Potash Manures	65.9	14.6	10.0	2.7	2.7	2.0	0.7	0.7	..	0.7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Nitrogenous Manures	83.3	8.0	5.9	2.1	..	..	..	0.7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Farmyard Manure	3.7	3.7	7.4	7.4	7.4	7.4	7.4	3.7	..	..	7.4	..	..	..	7.4	3.7	..	..	..	..	7.4	3.7	3.7	12.2	7.4

TABLE III. (Increase in cwt. per unit).

Percentage number of Plots giving following increase (in cwt.) per unit.*

	Less than ¼ *cwt.*	¼—½ *cwt.*	½—¾ *cwt.*	¾—1 *cwt.*	1—1¼ *cwt.*	1¼—1½ *cwt.*	1½—1¾ *cwt.*	1¾—2 *cwt.*	2—2¼ *cwt.*	2¼—2½ *cwt.*	2½—2¾ *cwt.*	2¾—3 *cwt.*	*Above* 3 *cwt.*
Phosphatic Manures..........	21.1	17.6	15.5	9.0	10.1	5.0	6.8	5.1	3.0	3.4	1.7	0.4	1.3
Potassic Manures	34.0	8.7	10.0	6.0	2.0	4.6	8.0	2.0	6.0	4.6	2.7	0.7	10.7
Nitrogenous Manure	49.6	5.2	3.9	2.6	3.9	5.2	2.0	2.0	4.0	2.6	1.3	3.3	14.4

* Units are 1lb. K2O; 1lb. Nitrogen: 1lb. Soluble or Total Phosphate, as the case may be.

(*c*) Weight of increase of crop caused by 1 lb. K_2O, 1 lb. N, or 1 lb. soluble phosphate in the case of superphosphate and dissolved bones, and 1 lb. of total phosphate in the case of slags and mineral phosphate. The increases per unit are given in the hope that they might serve for a useful comparison with results from other parts of the country.

Weight of Crop Increase per Acre (see Table I).

Increases of less than one ton per acre can be neglected as being either unprofitable or as coming within or near the range of probable error, and it is worthy of note that in the case of phosphatic manures only in 15.8 per cent. of cases was there an increase of less than twenty cwt., whereas 43.3 per cent. of potassic and 70.3 per cent. of nitrogenous applications resulted unprofitably. In the case of twenty-seven trials of farmyard manure there were no instances of increases of less than one ton per acre—more than half the increases were over ten tons per acre.

Reference to the table shows the importance of phosphatic manures and of farmyard manure for this crop in this area, and also that there is always a strong probability of potassic and nitrogenous applications being unremunerative. The latter class of manures can be left out of account for the swede crop if farmyard manure has been applied either in the autumn or in spring, but there are instances, though few, where there is a definite need of potash; in the cases under consideration there were 28.6 per cent. of instances where applications of potash resulted in increase of three tons or over per acre.

Percentage Increase (see Table II).

Increases expressed as percentages of the weight of crop on the control plot enable a truer examination of the results to be made than a consideration of the actual increases in weight. If for some reason, such as a dry spring, the root crop is light and averages only fifteen tons per acre, for instance, an increase of two tons per acre is as difficult an achievement and also as valuable as a four ton increase in a thirty ton crop grown in a more favourable season. The " percentage increase," i.e., 13.3 per cent. in this example, makes a fairer comparison possible, particularly in the case of results covering different seasons, soil conditions, etc.

An examination of Table II brings out very clearly the great importance of phosphatic manures in comparison with potassic and nitrogenous manuring in this area; whereas only in 20 per cent. of

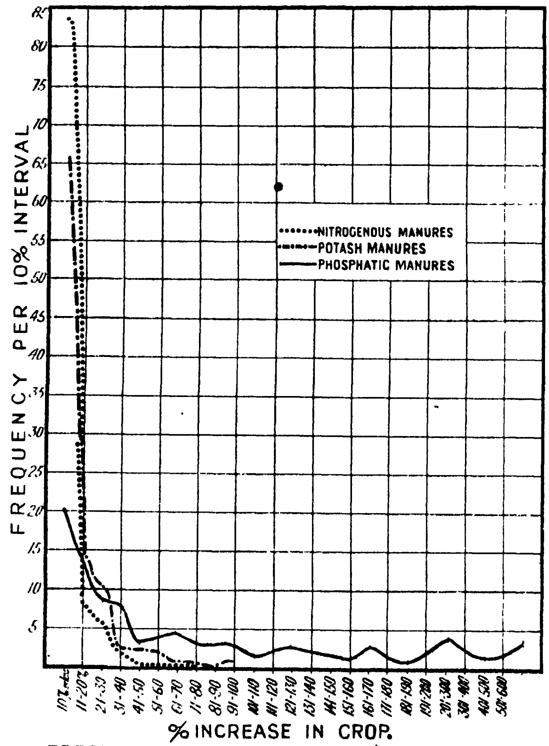
instances did phosphates produce an increase of 10 per cent. or less, this happened in 66 per cent. of cases of potassic and 83 per cent. of cases of nitrogenous applications; in other words

80 per cent. of phosphatic applications gave appreciable increase.

34 per cent. of potassic applications gave appreciable increase.

17 per cent. of nitrogenous applications gave appreciable increase.

Taking instances where large increases in the weight of crop were produced, nitrogenous applications only produced an increase larger than 40 per cent. in one case out of 152, potassic manures produced an increase larger than 80 per cent. in one case out of 150, whilst out of 232 applications of phosphates there were eighty-two cases of increases of above 80 per cent.; the overwhelming importance of



FREQUENCY CURVES SHOWING % OF CASES IN WHICH CERTAIN % INCREASES OF CROP WERE OBTAINED

phosphates for the swede crop in some soils may be seen in the fact that there were twenty-nine instances where the percentage increase in crop was greater than 200, and there were eight cases where 600 per cent. was exceeded, i.e., many soils were found where crops of swedes could not be grown without phosphatic manures. So well known is the need of phosphates for this crop in some parts of the

area that there used to be difficulty in persuading farmers to have a no phosphate plot of any size, it being regarded as so much waste land for the year.

Owing to the fact that only twenty-seven trials of farmyard manure were carried out, little comment is made; the results fall in with the general practice in the area of invariably giving farmyard manure to the swede crop. Only in one case out of twenty-seven was there an increase of less than 10 per cent.

The percentage increases given by phosphatic, potassic and nitrogenous manures are shown in graphic form in the frequency curve. On the horizontal axis is the percentage increase of crop in intervals of 10 per cent. (increased to 100 per cent. after 200), and the frequency per 10 per cent. interval is along the vertical axis, i.e., the percentage number of cases where a certain increase of crop was obtained. The curve representing phosphatic manures is of a different type from that representing potassic and also nitrogenous manures, the two latter being much steeper and ending halfway along the horizontal axis, showing that the results for these two classes of manures cluster round the low percentage increases.

Increase per Unit (see Table III).

It is not intended that a comparison should be made between the increase of crop given by the unit of phosphate, potash and nitrogen, since the cost of these units stands approximately in the ratio of 1:2:8. The object of including this table has been stated above.

Comparison of Effects of Superphosphate and High Grade Slag.

A comparison on the basis of the increase produced by a pound of soluble phosphate in superphosphate and a pound of total phosphate in slag would be the most suitable, but this is not possible in the case of any results prior to 1914, since there was a great discrepancy in the number of units applied per acre, there being often twice as many units applied in the slag as in the superphosphate dressings. Of twenty-two trials in which the same quantity of phosphate (200 lb. per acre) was applied in the case of both these manures, slag was superior in eleven cases and superphosphate in the remainder, and the average increase per crop was practically the same, viz., 1.03 cwt. per unit in the case of the former and 0.96 cwt. in the case of the latter.

Neglecting the number of units applied per acre there are fifty-nine comparisons of these two manures possible, and these will be taken

on the increase of crop in cwt. per acre, since the same control plot served for both manures.

Total number of comparisons = 59

Number of trials in which superphosphate proved superior	= 33
Number of trials in which slag proved superior	= 25
Number of trials in which no change	= 1
Average increase in cwt. per acre due to superphosphate	=165
Average increase in cwt. per acre due to slag	=165

Thus superphosphate and High Grade Slag have given practically identical results in these trials.

Comparison of High Grade with Low Grade Slag.

The results under review enable twenty-two comparisons to be made, but to these may be added eight others discussed in a separate report issued by the University College of North Wales, Bangor, viz., "Trials of phosphatic manures for swedes, 1921-24." Out of thirty trials in which these slags were compared the High Grade Slag was superior in only seventeen, but taking the average increase in weight of crop due to these manures, a clearer difference is shown in favour of the slag.

Average increase due to High Grade Slag	= 177 ± 14.10 cwt.
Average increase due to Low Grade Slag	= 122 ± 15.41 cwt.
Average difference in favour of H. G. Slag	= 55 ± 21.56 cwt.

The difference is thus nearly three times the probable error, making the odds heavy against the superior increase given by High Grade Slag being due to accidental circumstances.

Comparison of Gafsa with Superphosphate.

Gafsa phosphate is a finely ground North African mineral phoshate containing about 60 per cent. of total phosphate, and has come into prominence in many parts of North Wales on account of its beneficial effect on grassland. Only twelve comparisons on the basis of approximately equal amounts of total phosphate are possible in the period under review, but to these may be added ten others carried out since 1920 and discussed in the leaflet mentioned above.

Total number of comparisons = 22.

(Note.—200 lb. total phosphate in each case).

Number of cases in which superphosphate proved superior	= 15
Number of cases in which Gafsa proved superior	= 3
Number of cases in which no change	= 4

Average increase in cwt. per acre due to superphosphate = 143 ± 17½

Average increase in cwt. per acre due to Gafsa = 124 ± 17½

Difference in favour of superphosphate is 18½ ± 24½ cwt. As the difference is less than its probable error no importance can be attached to it since it might be due just as much to normal variation as to the superphosphate.

Summary and General Conclusions.

1. The results of a great many trials on the manuring of swedes carried out in North Wales during the past forty years are summarised.

2. The special dependence of swedes on an ample supply of readily available phosphate is clearly shown. In 232 tests the effect of phosphatic manuring was to increase the crop by at least 10 per cent. in 186 cases, and taking all the trials together the average increase in crop as a result of phosphate manuring was 148 cwt. or 49 per cent.

3. The effect of potash manuring was on the whole much less pronounced, and at two-thirds of the centres the applications probably proved unprofitable. At the same time, however, potash proved to be almost the determining factor at a few centres, e.g., at one centre in 1905 phosphate in the absence of potash gave an increase of 126 cwt., while potash added to the phosphate gave an additional increase of 137 cwt.

4. Nitrogenous manures rarely produced an increase of crop sufficient to cover the cost of manure.

5. In the great majority of trials phosphate was applied in the form of superphosphate, but basic slag and finely ground mineral phosphates proved to be efficient substitutes for superphosphate in the cases where they were tried.

RECENT RESEARCH IN PIG FEEDING.

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Progress involving selection and adaptation to a new environment is beset with pitfalls. The pig keeper in practising an arbitrary selection, and at the same time introducing a new environment,

represented by bricks and concrete, has placed himself in an artificial and, therefore, very dangerous position. Salvation is found in an exhaustive research into the natural diet and environment of the original pig, and an adaptation of the new conditions and foods to meet the fundmental needs of the animals.

Many pig keepers, recognising the difficulties of the situation, have made a move to return to more natural conditions by systems of open-air pig keeping, the high price of buildings proving an additional inducement in this direction. The general improvement in the health and well-being of the animals under these conditions has still further focussed attention on the natural food of the pig. Difficulties are, however, presented by the increased quantity of food required by the modern pig, selected as he is for rapid growth and early maturity. This bulk of food is handled more easily and with less waste in the modern sanitary pig styes; for it must not be forgotten that the heat of the body and energy for locomotion all come from the food consumed.

The alterations effected by breeding have, moreover, produced an animal which is more susceptible to inclement weather than his ancient forebears. Thus the pig keeper still builds sanitary modern pig styes and looks to research to supply information as to the needs of the animal in such an environment.

Practical observation has indicated that some fresh air and sunshine is most desirable; an open run facing south being considered necessary by many. In other cases the pigs are let out into a paddock for a period every fine day.

The fact remains that many stye fed pigs "go off their feet," more especially in the winter time, and although the material of the styes and sleeping places is frequently blamed, pigs much less well housed in the open fields or woods do not suffer to the same extent from this defect.

The object of the present article is to report the results of research work demonstrating that similar trouble may be of a dietetic origin and suggest how it may be prevented.

On comparing the food of the stye fed pig with that of his ancestors of the forest, his diet, though more abundant, consists of parts only of natural plants, while the digging for roots and the more animal part of his diet is denied.

Great care, prompted by economy in feeding has been, and rightly still is, taken in balancing the proportion of proteins, fat and carbohydrates, from which the greater part of the water-free substance of

the pig's body is made up, and from which heat and body energy are derived.

The source of the protein would seem to have practical importance, and the beneficial effects resulting from the use of fish meal, meat meals, and dairy bye-products, may well be due to the fact that they supply to the omnivorous pig the animal protein on which he has evolved, and which, as is now known, differs materially from similar compounds of vegetable origin.

The mineral constituents of the diet have also recently received much needed attention; the meal-fed pig is frequently deprived of one source of these bone-forming elements (the soil), while those inherent to the meals supplied are not only inadequate for the needs of the animal, but are badly balanced, a fact which recent research has demonstrated to be conducive of ill-health.

In practice many mineral mixtures have been recommended, but the work of Dr. Orr and the staff of the Rowett Research Institute emphasises the importance of this side of the subject.

There is yet another pitfall in passing from the natural to the artificial diet, for it has been proved by experiment that when pure proteins, fats, carbohyrates, minerals and water are fed, and fed in the right proportion, animals cannot live.

Lack of growth or the development of specific diseases follows from the use of certain foods which have been shown by experiment to be deficient in accessory food factors. At least four of these factors have been recognised and termed the Vitamins A, B, C, and D, the lack of each of which from an artificial diet results in well marked pathological symptoms.

These deficiency diseases can be prevented or cured by the administration of such foods as fresh milk or green plants, different fresh foods varying in the amount, as well as in the nature of the vitamin supplied.

All the four vitamins are found in fresh green food, and if this can be added *ad lib.* to the diet of the stye fed pig in the form of lucerne, grass (lawn mowings serve well), cabbage or kale, the dangers of vitamin deficiency vanish. Special substances can be given to ensure the presence of different vitamins. For fat soluble vitamins, cod liver oil up to one ounce per day may be given; for Vitamin B, dried yeast, and for Vitamin C, swedes.

The experiments conducted at the National Institute for Research in Dairying have been chiefly concerned with deficiencies of Vitamins A and D. The Vitamin A is connected with growth, but it is not easy to feed a diet so deficient in this factor as to arrest growth.

This was, however, accomplished on a diet of toppings (wheat offal), caseinogen (heated in a current of air for twenty-four hours), olive oil, chalk, and charcoal. [Golding, Zilva, Drummond and Coward, 1922]. The total gain in weight being reduced during thirty-five days to 1½ to 4½ lb. per pig. During the same period pigs from the same litter and in a similar environment gained 29 lb., the only difference being that the olive oil was replaced by cod liver oil and the wood charcoal by animal charcoal.

The cod liver oil was demonstrated to be the more important factor, as where the oil alone was changed a growth of 20½ to 21½ lb. took place, whereas when the wood charcoal was replaced by animal charcoal a growth of 13 to 15¾ lb. only was observed during the selected period of the experiment (thirty-five days).

In these experiments, although the pigs in the olive oil groups (deficient in Vitamins A and D) went "off their feet," true rickets was not observed when a histological examination of their bones was made.

Our experiments on "Rickets" in pigs might have been inconclusive had it not been for a series of experiments in which the value of dried separated milk was being tested, and in which the pigs displayed rachitic symptoms.

These experiments were repeated on ten animals fed on a diet consisting of toppings, dried separated milk, and barley meal. Animal charcoal and chalk were also added to supply the necessary mineral requirements. [Zilva, Golding, and Drümmond, 1924].

The pigs were kept in a roomy animal house and were allowed sufficient exercise, direct sunlight being, however, excluded.

On this diet all the animals grew well, but in two or three months went "off their feet," the histological examination of the bones of those which were slaughtered showing true rickets in eight cases out of ten.

Other experimental animals, after exhibiting the same symptons and being definitely "off their feet," were cured as follows:—

(1) In the same stye and under exactly the same conditions except that ¼ to ½ an ounce of cod liver oil was added to their diet.

(2) In the same stye and under exactly the same conditions except that full cream fresh milk replaced the separated milk given up to the time they went "off their feet," see figs. 1 and 2.

(3) On the same diet by allowing the pigs out into a run where they basked in direct summer sunshine.

FIG. 1.

PHOTOGRAPH OF A PIG WITH TYPICAL RICKETS PRODUCED IN A STY IN THE ABSENCE OF DIRECT SUNSHINE ON A DIET OF DRIED SEPARATED MILK, TOPPINGS, BARLEY MEAL AND MINERALS. WEIGHT OF PIG 126 LB.

FIG 2.

THE SAME PIG, 45 DAYS LATER, PARTLY CURED BY REPLACING THE SEPARATED MILK WITH ONE QUART PER DAY OF FRESH FULL CREAM MILK. WEIGHT 158 LB.

The conclusions drawn were that the diet was deficient only in the antirachitic vitamin, which deficiency was responsible for the production of the disease.

The growth factor Vitamin A was sufficient in the dried separated milk to admit of good growth.

An apparently similar case in which pigs "went off their feet" in farm practice on a diet consisting largely of separated milk has come to our notice, and the well known frequency of the trouble indicates the importance of some source of Vitamin D for stye fed pigs, more especially when such an otherwise good food as separated milk is fed. Half an ounce of cod liver oil will serve in the absence of some natural fresh green food. Access to soil and green grass is the better form of management and tempers the artificial environment of the modern stye. It is improbable that we yet know all the benefits to health and well-being associated with "out of doors," and though food and labour may be economised by the modern stye it is well to make at least a partial concession to a more natural environment.

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SILAGE INVESTIGATIONS AT BANGOR.

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Silage is a succulent feeding stuff formed by storing green fodder crops in such a way as to exclude air; this is generally carried out in a Silo, which may be of concrete, wood, steel, etc., though good silage can be made by storing in clamps or in the form of a stack. The process of making silage is termed Ensilage. Silage may be made from any green crops (except cruciferous crops such as rape), for example, grass, cereals, peas, vetches and mixtures containing these, but it should be noted that if poor material is put into the silo, the resulting silage will be of inferior quality.

In May, 1924, a concrete silo was erected at the College Farm, Aber (University College of North Wales), so that ensilage and the feeding of silage might be investigated under North Wales

conditions. The following particulars of the silo may be of interest.

Height to eaves	40 ft.
Internal diameter	14 ft.
Thickness of walls	6 inches.
Internal dimensions of chute	2 ft. × 2 ft.
Doors (six)	2 ft. 2 in. × 4 ft.
Internal diameter of concrete blowpipe	8 in.
Total cost of silo, including all material and labour, except carting from station	£237 10 0
Cost of the cutter and blower used for filling	£ 80 0 0
Estimated capacity	150 tons.
Amount put into silo in 1924 (wet condition) ...	140 tons.
Amount put into silo in 1925 (dry condition) ...	120 tons.

Ensilage is often recommended as a means of providing succulent winter food at a lower cost and with more certainty of success than roots. The problem of the substitution of silage for roots has several aspects and involves more than a comparison of the costs of production of these crops. The following are some of the points to be considered and which will be investigated at Aber.

I. Silage in Dry Districts.

Silage is a more certain crop than roots in a dry district, and this accounts for its growing popularity in the Eastern Counties of England. Crops for silage may be sown in the autumn, thus taking full advantage of the autumn and spring, which in dry districts are often the only favourable growing seasons. The root crop, however, often suffers from drought before it has taken strong root, and it is an uncertain crop in those parts of the country where the summer rainfall is low.

II. Silage in Wet Districts.

All the crop put into the silo in 1924 was in a thoroughly wet condition, but produced excellent silage of the " acid brown " type. Had the crop been less mature, a sour silage would probably have been obtained, but the effect of the degree of maturity of the crop, weather conditions while fiilling, rate of filling and degree of heating in silo, etc., on the quality of the silage is under investigation and will require several years' work. While discussing the advantage of ensilage under wet harvest conditions it may be stated that the silo has been found useful at the College Farm for making silage of oats which had been beaten down by wind and rain. In this way all the food value of the crop was preserved without the risk and expense of harvesting a badly laid crop in a wet season.

III. Cost of Roots and Silage.

It is claimed that silage provides succulent winter food at a smaller cost per ton than the root crop, and the heavy cost of root-growing has been responsible for many of the silos in this country.

IV. Composition of Roots and Silage.

Although silage is a succulent food on which stock can thrive without the addition of any other form of succulent food, it has a composition very different from that of roots. Not only is the percentage of water different (roots 90 per cent., silage 71.4 per cent. water), but the composition and digestibility of the dry matter itself is different.

Composition of Pea and Oat Silage and of Roots.

	Silage.	Roots.	Analysis of Dry Matter. Silage.	Analysis of Dry Matter. Roots.
Moisture ...	71.4	89.3	—	—
Crude Protein ...	2.9	1.0	10.3	9.4
Crude Oil ...	1.5	0.1	5.2	0.9
Crude Fibre ...	8.8	0.7	30.8	6.6
Soluble Carbohydrates	13.7	8.2	47.8	76.6
Ash ...	1.7	0.7	5.9	6.5
	100.0	100.0	100.0	100.0

Silage analysis by Mr. W. McLean (1924 crop at Aber). Roots analysis from "Rations for Live Stock," by Professor T. B. Wood, F.R.S.

On the basis of figures given in "Rations for Live Stock"

80 per cent of the dry matter in roots is digestible.

59 per cent. of the dry matter in silage is digestible.

Thus roots may be regarded as "dilute concentrates" (Armsby), whilst silage, which contains a quantity of crude fibre, may be regarded as succulent hay. When silage is introduced into a ration to replace roots, either partially or wholly, the hay and, in many cases, the concentrated portion of the ration must be altered if the ration is to be kept balanced.

V. Silage as a Cleaning Crop.

The root crop is grown not only for the purpose of providing succulent food for the winter, but also to give the land a thorough cleaning and aeration, thus benefiting the succeeding crops in the rotation. Silage crops also benefit the land in this way, though probably to a smaller degree.

They are efficient smothering crops, and even if the crop is too thin to smother out weeds it is cut before the latter have time to shed their seeds; in addition, an autumn sown silage crop is removed in time to permit of cleaning the land by a "half or bastard fallow."

VI. Weight of Food per acre from Silage and Roots.

The root crop provides a heavier weight of food per acre than silage crops in moist conditions such as obtain over the greater part of Wales. Thus 1924 figures from the College Farm, Aber, give:—

Roots.	Silage.
30 tons per acre Mangels. 10.5 % dry matter. 67 cwt. of dry food per acre. 50 cwt. of digestible food.	10 tons per acre Peas and Oats. 28.6 % dry matter. 57 cwt. dry food. 34 cwt. of digestible food.

An autumn sown silage crop, however, enables a second crop, such as rape, to be taken if there is no need to bastard fallow the ground.

Results of Experiments at Aber, 1924, 1925.

(*a*) *Crops Grown.*

The wet conditions prevailing in the autumn of 1923 and 1924 prevented the sowing of winter crops, but the following is the mixture that was intended:—

126 lb. Winter Oats (Bountiful) 28 lb. Winter Barley (Excelsior) 90 lb. Vetches (Winter)	per acre.

Previous experimental work in the growing of green crops for dairy cows helped in selecting mixtures for silage crops, and the spring sown (1924 and 1925) mixtures consisted of:—

80 lb. Grey Field Peas 168 lb. Victory Oats 15 lb. Italian Rye Grass (for grazing afterwards)	per acre.

In addition, a seeds crop was ensiled both this year and last year in order to compare it with such crops as oats and peas. This year's seed crop was obtained by sowing the following mixture in last year's pea and oat crop:—

Late Flowering Red Clover	8 lb.	per acre.
Italian Rye Gress	7 lb.	
Perennial Rye Grass	4 lb.	
Cocksfoot	3 lb.	
Timothy	2 lb.	

Such crops should be cheaper to produce than arable crops. The yields per acre were as follows:—

	1924.		1925.
"Seeds" crop ...	9 tons, 5 cwt.	...	7 tons, 1 cwt.
Pea and Oat Crop ...	10 tons, 0 cwt.	...	7 tons, 17 cwt.

The Clover and Rye Grass Silage made in 1924 appeared to be in every way as good as that made from Peas and Oats, but a feeding trial will be necessary to complete the comparison of these two crops as silage crops.

(*b*) *Cost of Cutting, Carting and Filling Silo*, 1925.

In addition to the cost of man and horse labour an additional charge has to be made for the capital standing on the silo and cutter, and also for depreciation of both. Charging 5 per cent. interest on capital, 2½ per cent. depreciation for silo, and 10 per cent. for cutter, there is thus a total annual charge of £30, or an item of approximately 4s. 6d. per ton of silage irrespective of any of the ordinary costs; it must be realized that 4s. 6d. per ton for a fairly watery food of this nature corresponds to about 15s. per ton for hay. The total labour requirements for filling this year were as follows:—

Cutting (sufficient in half a day) for next day's filling:—
One man, two horses cutting.
Two extra men in a heavy tangled crop of Oats and Peas to pull the cut material out of the way of the reaper.

Carting and Filling (22 tons a day dealt with):—
Three men and three horses carting.
Two men pitching.
One man feeding cutter.
Two men treading in silo.
Bailiff supervising and tending tractor.

Total labour:—

684 man hours ... ... }	£28	4	0
299 horse hours ... ... }			
Paraffin, lubricating oil	6	10	0
	£34	14	0
(118 tons in silo) or	6/- per ton.		
Interest on capital, depreciation	4/6 per ton.		

Making 10/6 per ton of silage.

(*c*) *The Feeding of Silage.*

The silage was fed to all the horned stock at Aber, the dairy cows receiving about ½ cwt. per day. In a trial with sixteen in-calf heifers, eight were fed on a roots ration, eight on a silage ration, and the animals weighed fortnightly for eight weeks, when it was found that

there was no appreciable difference in weight produced by the two rations. The rations were as follows:—

30 lb. silage.	30 lb. roots.
8 lb. straw.	14 lb. straw.
2½ lb. mixed concentrates.	3½ lb. mixed concentrates.
Thus 30 lb. silage replaced	30 lb. roots.
	6 lb. straw.
	1 lb. cake.

VII. Conclusions.

As far as any opinion can be formed up to the present the silo is likely to be a useful addition to the College Farm, where a large head of cattle, including forty dairy cows, has to be wintered. The chief drawback is that the silo has had to be filled during the hay harvest, though this was an advantage in 1924, when the silo was filled under weather conditions which were impossible for hay making. Autumn sown crops should, however, enable a part at least of the silo to be filled before the hay harvest, thus relieving the pressure of work in July, and it will always be found that a smaller area will be required for hay when ensilage is practised.

The initial charge of 4s. 6d. per ton, representing interest on capital and depreciation, is a serious item and is not much less than the cost of labour (man and horse) and fuel for cutting, carting and filling. The only way of reducing this item is on large farms where silos holding about 300 tons could be used, thus spreading the charge over a greater tonnage; a cutter and blower costing from £80—£100 is an expensive implement to be kept idle for the greater part of the year and only to be used for dealing with 120—140 tons of green fodder. A cheaper, less durable, type of silo would require a smaller outlay of capital, but depreciation would have to be charged at a higher rate and it is doubtful whether, in the long run, any saving would be effected.

THE BACTERIOLOGICAL EXAMINATION OF MILK FROM BRECONSHIRE AND RADNORSHIRE.

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Introduction.

It has been thought that a brief survey of the results obtained in the Clean Milk Competition organised in Breconshire and Radnor-

shire during the first three months of 1925 would be of general interest seeing that this event afforded the first opportunity of studying the improvement that can be reasonably expected in the ordinary retailed milk of Wales. Such a study is admittedly of importance at the present stage in the development of the milk industry, when certain specific standards of cleanliness are necessary before the milk can be recognised as a marketable commodity of the first order. While it is possible that the standards in existence to-day may be modified as our experience in the control and eradication of disease increases, it is beyond doubt that an enlightened public will be as concerned in ensuring a clean milk as it is in obtaining a wholesome water supply. Under these circumstances, it is of practical importance for everyone interested in milk production, and especially for those that produce milk on a relatively small scale with limited resources of capital, to know what changes are really essential in their present methods of production before they can produce a commodity which beyond doubt belongs to the first order of cleanliness. A natural question asked by many is whether the milk ordinarily retailed in Wales at present is the inevitable result of unfavourable environment which it is difficult and impracticable to alter, or whether it is an article which can often be vastly improved by simple means without the necessity for expensive and elaborate changes. In the competition under consideration there were important differences in the construction of the cowsheds, wide fluctuations in the size of the herds, and marked contrasts in the nature of the dairy equipment on each farm. Such characteristic features added considerably to the value of some of the results, as they served to throw light on the effect which diverse conditions have on the production of clean milk, and to bring into clearer relief those fundamental factors that are essential before success can be achieved.

Eleven different farms distributed over the two counties mentioned above took part in this competition, and milk samples were forwarded at regular fortnightly intervals for chemical and bacteriological examination. These samples were carefully taken so as to be representative of the milk of the whole herd, and a chemical analysis was conducted at the laboratory so as to check the representative character of each sample. In addition to these regular samples, the milk was also sampled by members of the county staff without notice at irregular intervals, and these samples afforded an additional valuable check on the genuineness of the fortnightly samples.

Methods of Testing the Milk Samples.

The aim of the various tests to which the milk was subjected was to determine its keeping qualities, its suitability for consumption and for the making of good dairy products. With the object of comparing the keeping qualities of the various samples they were placed in an incubator on arrival at the laboratory, the temperature of which was maintained at 15° C. (59° F.). The samples were tasted at intervals of half a day and rejected either on the development of a taint or on becoming sour.

To determine the amount of dirt in the milk, a definite quantity was taken by the County Officer sampling the milk at the farm, and filtered through a disc of cotton wool. This became more or less dirty according to the state of the milk, and the discs obtained in this way were dried and compared with each other. The samples forwarded to the laboratory were subjected to a count of the number of bacteria in each cubic centimeter of the milk, as this afforded further valuable information regarding the state of cleanliness of the samples. This count was accomplished by taking a known volume of the milk and introducing it into a medium which contained all the ingredients necessary for the development of the bacteria. After being allowed to develop in this medium for a period of forty-eight hours at 38° C. (100.4° F.), the colonies, each of which had grown from a micro-organism, could be counted; the number of bacteria present in 1 cc. of the milk being then calculated from this count.

The milk samples were also tested for the presence of coli-organisms, the smallest quantity of milk in which such bacteria were present being determined. These organisms are among the most objectionable met with in dairy practice, as many species give rise to disease, while they all are capable, if present in appreciable numbers, of spoiling the milk for cheese-making. They are usually brought into the milk with cow dung, and afford the most sure indication of the extent to which milk has been contaminated from a source of this nature. These coli-organisms were searched for by introducing known volumes of milk into a medium which favours the growth of these bacteria; but does not favour the development of other organisms that are relatively harmless. The presence of coli-organisms was betrayed by the fact that milk sugar, introduced into the medium, was decomposed with the production of gas (mainly carbon dioxide and hydrogen) on keeping the milk in contact with the medium for three days at 38° C. (100.4° F.).

Keeping Qualities of the Milk Samples.

In Table I the total time, reckoned from the hour of milking, that the milk kept sweet and free from taints is indicated.

TABLE I.

Total Keeping Time of Milk from Hour of Milking.

	Remarks.	Mean Temp. on arrival at Laboratory.	Keeping Time (Days). Max.	Min.	Average.
Series 1.	Afternoon Milk.	51.2°F.	4.5	2.5	3.40
Series 2.	Do.	54.6	4.0	2.5	3.13
Series 3.	Do.	52.0	4.5	3.0	3.55
Series 4.	Do.	51.2	4.5	2.5	3.77
Series 5.	Morning Milk.	51.7	5.0	3.0	4.27
Surprise Samples.	Afternoon Milk.	52.9	5.0	2.5	3.64
Ord. Retailed Milk.	Morning Milk.	52.1	3.0	2.0	2.50

The first four series and the surprise samples represent afternoon milk, and the keeping time includes a period of twenty hours in transit prior to being placed in the incubator at 15° C. (59° F.). Series 5 and the retailed milk samples represent morning's milk, the keeping time including a period of twenty-eight hours in transit before incubation. Each series and the surprise samples include the milk forwarded from every herd taking part in the competition. The ordinary retailed milk includes a number of samples which were purchased from time to time at different centres in the counties and forwarded for analysis side by side with the competitors' milk.

From Table I it is seen that the keeping qualities of the clean milk in every case stand out in marked contrast to those of the ordinary retailed milk of the counties. The keeping qualities of the clean milk from Series 5 afford the best comparison with those of the retailed milk, as the milk from this series, like the retailed milk, represents the morning's milking. It was found during the course of the competition that the morning's milk, although containing somewhat more bacteria than the evening milk, possessed better keeping qualities. This was to a certain extent due to the fact that the morning milk remained for eight hours longer than the afternoon milk at atmospheric temperature prior to incubation.

Another reason, however, was that the morning milk showed a greater freedom from taints than the afternoon milk.

Several of the afternoon samples that contained an abnormally small number of bacteria were found extremely prone to develop taints, which militated appreciably against their keeping qualities, in spite of the fact that they did not clot on boiling until a considerably later time. The somewhat higher number of bacteria present in the morning's milk seemed to be a contributory factor in keeping down the unfavourable agencies responsible for the taints, with the result that the morning's milk on the whole showed better keeping qualities than the afternoon's milk. It is seen from the table that while the samples from morning's milk in the competition kept good for an average period of 4.27 days, the samples of retailed milk only kept on an average for 2.50 days.

Dealing with the afternoon milk represented by Series 1—4 and the surprise samples, it is seen that the behaviour of the surprise samples confirms the very satisfactory keeping qualities of the milk in the ordinary samples. It should be pointed out that each series followed the other in point of time, and that the reason why a somewhat lower keeping interval was obtained in Series 2 as compared with Series 1 was due to the fact that the samples for the second series were taken during the most unfavourable weather conditions experienced in the course of the competition. These unfavourable conditions are reflected by the mean temperature of the milk on arrival at the laboratory, which is seen from Table I to be decidedly higher than the mean temperatures for the other three series. When allowance is made for this disturbing factor it is plainly seen that the keeping qualities of the milk improve steadily from one series to another. This improvement is the more remarkable when the extraordinary good keeping qualities of the first series is taken into account, and clearly shows how the interest of the competitors in their work increased as the trial proceeded, and the results of some of their previous endeavours became known.

Bacteriological Examination of the Milk.

1. *Number of Bacteria present in the different samples.*

In Table II the average number of bacteria in 1 c.c. of the milk from each series of samples is given, and for the purpose of comparison the results obtained for the ordinary retailed milk from the counties are also included.

TABLE II.

Bacterial Content of Brecon and Radnor Milk Samples received during period, January—March, 1925.

	Remarks.	No. of Bacteria present in 1 c.c. of Milk.		
		Maximum.	Minimum.	Mean.
Series 1.	Afternoon Milk.	150,000	890	29,000
Series 2.	Do.	109,000	1,900	33,500
Series 3.	Do.	65,000	400	12,500
Series 4.	Do.	82.500	300	11,980
Series 5.	Morning Milk.	160,000	300	20,800
Surprise Samples.	Afternoon Milk.	350,000	450	37,000
Ord. retailed milk.	Morning Milk.	8,390,000	119,000	4,032,000

The above total numbers of bacteria found present in the various samples would depend chiefly on the state of cleanliness of the udder and the teats of the cow, on the cleanliness of the vessels with which the milk came into contact, and also on the temperature of the milk.

By far the most noteworthy fluctuation in the numbers of bacteria shown in Table II is that found between the clean milk and the ordinary retailed milk, the latter milk containing on the average well over a hundred times the number of bacteria found present in the clean milk. These retailed milk samples were tested side by side with the milk forwarded by the competitors, the same procedure being rigorously adhered to in all cases. Being morning milk, the results of the retailed milk samples are strictly comparable with those obtained in Series 5. The difference between Series 5 and the other series in the competition is, however, negligible compared with the difference between the retailed milk and the clean milk. While the number of bacteria in milk may show considerable fluctuations having no important significance, the abnormally high figures obtained for the retailed milk samples indicate that the milk had been seriously contaminated with cow dung, earth or decaying straw, materials that swarm with bacteria, many of which are of an exceedingly harmful nature. The examination of milk produced outside the counties of Brecon and Radnor has shown that samples of retailed milk frequently give high counts of this order.

The bacterial count of the surprise samples agreed well on the whole with those obtained for the ordinary samples, but there were one or two surprise samples giving comparatively high counts which had an influence in raising the average figure for these surprise sample counts. Taking weather conditions into consideration, there

was a steady diminution in the number of bacteria from Series 1—4. While Series 1—4 represented afternoon milk, Series 5 was sampled from morning's milk, and a somewhat higher bacterial count was expected, as during the period of the competition the cows were kept indoors. The difference between evening and morning milk is, however, exceedingly small, the counts obtained in both cases being well within the limits desired.

2. *Presence of Coli Organisms in Milk.*

Table III gives an indication of the extent to which coli organisms were found present in the different samples under examination. Column A gives the precentage number of samples which were found to be entirely free from the presence of such organisms. Column B gives the percentage number of samples which were found to contain coli bacteria in 1 cc. of the milk. Similarly, columns C, D and E give the percentage of the samples found to contain the organism in 1/10, 1/100, and 1/1,000 c.c. of the milk respectively.

TABLE III.

Showing the Extent to which the Milk was contaminated with Coli Organisms.

	Percentage of Milk Samples in which				
	No coli orgms. were pres. A.	Coli orgms. were pres. in 1 c.c. B.	Coli orgms. were pres. in 1/10 c.c. C.	Coli orgms. were pres. in 1/100 c.c. D.	Coli orgms. were pres. in 1/1000 c.c. E.
Series 1.	55	45	—	—	—
Series 2.	55	18	18	9	—
Series 3.	73	27	—	—	—
Series 4.	91	—	9	—	—
Series 5.	55	9	36	—	—
Surprise Samples.	64	22	7	7	—
Ord. Retailed Milk.	—	—	—	20	80

From Table III it is seen that 80 per cent. of the ordinary retailed milk contained coli organisms in such a small volume as 1/1,000 c.c., a result which fully confirms the highly unsatisfactory nature of ordinary retailed milk. On the other hand it is seen that most of the samples in the competition were entirely free from the presence of such organisms, and that a steady improvement was effected as the trial advanced, with the result that in Series 4 coli bacteria were absent from as large a proportion as 91 per cent. of the samples.

On comparing Series 5 (morning milk) with Series 4 (afternoon milk) it is evident that the elimination of coli organisms is a more difficult problem under winter conditions in the case of morning milk, but even in Series 5 no sample was contaminated to such an extent that coli organisms were detected in 1/100 c.c.

3. *Standards attained by Milk Samples.*

A question of considerable interest is the extent to which the competitors succeeded in producing milk up to the standards relating to clean milk which are at present in existence. The most exacting of these are the Certified Milk Standards, to reach which the milk must not contain more than 30,000 bacteria per c.c., and no coli organisms in 1/10 c.c. For Grade A milk there must not be more than 200,000 bacteria per c.c. and no coli organisms in 1/100 c.c.

Table IV indicates the proportion of samples in the competition that were successful in reaching these standards:—

TABLE IV.

Percentage of Samples in Brecon and Radnor Clean Milk Competition that reached Certified and Grade A Standards.

	Remarks.	Certified Milk Standards.		Grade A Standards.	
		For Bacterial Count.	For Coli Organisms.	For Bacterial Count.	For Coli Organisms.
Series 1.	Afternoon Milk.	82	100	100	100
Series 2.	Do.	64	73	100	91
Series 3.	Do.	91	100	100	100
Series 4.	Do.	91	91	100	100
Series 5.	Morning Milk.	91	64	100	100
Surprise Samples.	Afternoon Milk.	79	86	93	93

Table IV shows that towards the end of the competition (series 3, 4) the efficiency of the competitors' methods enabled them to forward afternoon milk of such a high quality that 91 per cent. of the samples reached the required standards for Certified Milk, while all the samples were well within the limits for Grade A milk. A lower percentage of the samples of morning milk (Series 5) attained Certified Standards, on account of a larger proportion of coli organisms in this milk. All the morning milk, however, succeeded in attaining Grade A standards. The figures given for the surprise samples confirm the fact that the milk maintained a remarkably high standard of cleanliness throughout the competition.

Further tests to which the milk samples were subjected.

The tests detailed above, on which the relative merits of the milk samples were adjudged for the purpose of the competition, were supplemented by one or two others that are frequently used on the Continent. These included the rate at which methylene blue is decolourised by the milk,[1] a change depending largely on the number of micro-organisms present in the milk sample. For this experiment of 1 c.c. of a methylene blue solution of a definite strength was added to 40 c.c. of the milk, the solution mixed and kept at a temperature of 38° C. (100.4° F.). Barthet and Jensen have shown that it is possible to grade milk by means of this test into four classes:—

Class 1. Good milk not decolourised in 5½ hours.

Class 2. Milk of fair average quality decolourised in less than 5½ hours but not less than 2 hours.

Class 3. Bad milk decolourised in less than two hours but not less than twenty minutes.

Class 4. Very bad milk decolourised in twenty minutes or less.

With the exception of one or two samples all the samples in the competition were shown to belong to the first class.

Information regarding the quality of the milk especially its suitability for infant feeding and for the making of cheese, was obtained by noting the type of curd produced on allowing 40 c.c. to ferment at a temperature of 38° C. (100.4° F.). A very marked difference in the type of curd was noticeable between those samples from which coli organisms were absent and those samples which evidenced the presence of coli organism in 1/10 c.c. or less of the milk. Thus, while most of the clean milk samples produced a satisfactory even curd, the curd from the ordinary retailed milk was badly blown owing to the gas producing organisms so prevalent in these samples.

The effect of the conditions of Milking on the Bacteriological Results.

As previously indicated, there were marked fluctuations in the environment and in the conditions of milking at the various farms taking part in this competition.[2] A comparison of either the equipment or the methods of procedure with the bacteriological results forces one to conclude that a rigid adherence to a code of

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1 Dairy Bacteriology. *Orla Jensen*, p. 166, *et. seq.*

2 Clean Milk Competition, 1925. (The Brecon County Times, Ltd.). Additional information of value was also obtained through the courtesy of Mr. David Thomas, Agricultural Organiser for Brecon and Radnor.

rules is unnecessary, and that the farmer has a wide latitude within which he can safely vary his procedure to suit his own peculiar circumstances. This is well illustrated by the effect of the methods adopted in the cleaning of the utensils.

A. *Cleaning of Utensils.*

While some steamed and others boiled their utensils, a third group only subjected them to a scalding operation. In all cases where the vessels received immediate and proper attention the three methods proved effective, and four out of five of the competitors who merely scalded almost invariably succeeded in producing certified milk, clearly showing that utensils can be maintained in a satisfactory condition where there is a good water supply even when a steamer is not available. As is seen from the following table, the milk dealt with in steamed vessels, while not showing a lower bacterial count, possessed a greater freedom from coli organisms and had somewhat better keeping qualities than that kept in vessels treated by other methods.

TABLE V[3].

The Effect of the Treatment of Utensils on the Quality of Milk.

Treatment of vessels.	Av. no. of bacteria per c.c.	% samples in which coli organisms were present.	Average keeping time.
1. Steamed.	18,230	14	3.90
2. Boiled.	9,680	33	3.50
3. Thorough scalding.	14,150	35	3.60
4. Unsatisfactory scalding.	98,700	80	3.30

B. *Methods of Straining.*

The use of cotton wool strainers showed no appreciable effect when compared with cloths in diminishing the amount of sediment present in the milk. This was doubtless due to the fact that such clean conditions were being observed that the milk even without straining would contain a negligible amount of sediment. It is worth noting, however, that the four competitors who succeeded in bringing the bacterial content of the milk to the lowest level used cotton wool strainers.

[3] These results apply to the comparatively favourable climatic conditions prevailing during the course of the competition, and a similar comparison under decidedly less favourable conditions will be necessary before the advantages to be derived from steaming can be finally gauged.

C. *Cooling.*

As this competition was conducted during winter under comparatively favourable temperature conditions, the question of cooling the milk was of much less importance than it would have been in summer. There is no relationship whatsoever between the temperature of the milk at the farm immediately after cooling either with the keeping qualities or with the number of bacteria present in the milk. Indeed we find that the milk from the farms with no cooling contrivance often compares favourably with that from those farms where the most efficient coolers have been used. The reason for this is that all the milk samples were naturally cooled by the cold atmosphere prevailing at the time, and one would expect different results in warm weather. Such scrupulous cleanliness has, however, been observed at some of the farms without coolers that the milk at the end of more than a day only contained a few hundred bacteria, and it is probable that such a carefully prepared commodity would show quite satisfactory keeping qualities under much less favourable conditions than existed during the period of the trial.

That temperature does enter as a factor in this competition is shown by the fact that a somewhat higher average bacterial count was obtained for Series 2 than for the other series, the mean atmospheric temperature during the sampling of this series being somewhat higher than that prevailing during the taking of the remaining samples (see Table I). The significance of the prevailing temperature is also seen from Table VI, A and B. Table VI, A, shows the bacterial content and keeping qualities of those samples from each series giving the highest temperature on arrival at the laboratory, while Table VI, B, indicates the results for those samples in each series having the lowest temperature on arrival.

TABLE VI.

A. Bacterial Content and Keeping Qualities of Milk Samples showing highest Temperature on arrival at Laboratory.

Sample.	Temp. on. arrival. °F.	No. of bacteria per c.c.	Coli. organisms present in	Keeping time from hour of milking.
Series 1. No. 2.	57.2	18,600	1 c.c.	3
Series 2. No. 2.	60.0	109,000	1/10 c.c.	3
Series 3. No. 3.	55.4	5,400	Absent.	3
Series 4. No. 6.	59.0	82,500	Absent.	3½
Series 5. No. 2.	60.0	15,900	1 c.c.	4½

B. Bacterial Content and Keeping Qualities of Milk Samples showing lowest Temperature on arrival at Laboratory.

Sample.	Temp. on. arrival. °F.	No. of bacteria per c.c.	Coli. organisms present in	Keeping time from hour of milking.
Series 1. No. 11.	48.2	3,900	1 c.c.	3½
Series 2. No. 9.	52.7	1,000	Absent.	4
Series 3. No. 1.	48.2	1,100	Do.	4
Series 4. No. 8.	46.0	1,600	Do.	3½
Series 5. No. 8.	48.0	4,300	1/10 c.c.	4

It is seen from Table VI that those samples showing the highest temperature on arrival gave a considerably higher count than the low temperature samples, and were often inferior in keeping qualities. At the same time, the temperature fluctuations experienced during the course of this competition were of secondary importance, and other factors were of far greater significance in determining the nature of the results.

D. *Precautions against contamination with dust.*

Considerable care must undoubtedly have been taken by all the competitors so as to minimise the amount of dust that found its way into the milk, but some exercised more care than others in this connection. There is evidence that this extra care was a contributory factor towards improving the quality of the milk. Three competitors fed hay either immediately before or during milking, while the milking was carried out in open pails. One would naturally expect both these factors to increase the risks arising from contamination with dust. On the other hand, out of the eleven competitors there were three that exercised care in allowing a suitable interval between feeding and milking, and also had resort to covered pails. Other things being equal such competitors as this last type would be at an obvious advantage. A summary of the results obtained by these two types of competitors is therefore given as being of special interest in that the differences in the results will to a certain extent at least be due to the more effective elimination of dust by the last mentioned type of competitor (see Table VII, page 180).

E. *The Personal Factor.*

It is evident when the results are surveyed as a whole that the personal factor is by far the most significant in its effect on the production of clean milk in this competition, and serious disadvantages, due either to a lack of proper equipment or to

TABLE VII.

Code Nos. of competitors.	Remarks.	Av. no. of bacteria per cc. of milk.	% of samples in which coli organisms were present	Keeping time.
3, 7, 10.	Hay fed immediately before or during milking. Open pails used.	25.900	43	3.5
1, 4, 5.	Suitable interval between feeding and milking. Covered pails in use.	1.730	7	4.0

unsatisfactorily constructed buildings were successfully overcome by relentless personal application to the details of the work. This factor came into play throughout the various processes in the procurement of the milk, and it happened that those farms with the cleanest cows possessed also the cleanest cowsheds, milkroom and utensils. The same factor had also a great bearing on the attention paid to small but important details such, for example, as the regular use of clean overalls, the cleansing of the udders, and the use of clean stools. While it is impossible to trace the exact significance of these details in a competition where such a large number of factors are involved, it would be difficult to overestimate the cumulative effect of due attention to simple and obvious points of this character. Effective personal control is much more difficult in the case of the large herd than the small one, and the equipment and type of building become of far greater significance as the size of the herd increases. This competition shows that the small farmer can undoubtedly succeed by personal care and attention without the favourable equipment and conditions that would be essential when producing milk on a large scale.

FRUIT CULTURE IN GRASS ORCHARDS.

By G. H. Hollingworth,
Agricultural Organiser for Gloucestershire.

There is something quaintly picturesque about the old orchards as one finds them attached to farmsteads throughout the country, particularly in the west. They belong to a period in history before commercialism in fruit growing had actually begun. In fact, the growing of apples in grass orchards was general many years before

the introduction of more modern methods, and the object was to produce fruit for home consumption and to grind into cider. It is customary in these days to criticise the old farm orchard, and viewed in the light of present day knowledge there are grounds for this criticism, but, on the other hand, one has to take into account the facilities that were available when the orchards were originated. There were few standard varieties of apples, little was known about propagation, and the method of raising trees was mostly as seedlings, which grew from the pips thrown out with the pomace from the old stone cider mills. This accounts for the large number of unnamed or locally named apples that are seen in old orchards. To their credit, however, the farmers in those early days knew where to plant the orchard; it is generally in the right place, close to the buildings and handy to provide grazing for calves, pigs, and ewes and lambs. These ancient orchards, in fact, were planted to serve a specific purpose by practical farmers who knew what they were doing, and if the growing of apples in grass orchards was a sound business proposition centuries ago it is even more so at the present time, provided that the conditions of soil and situation are suitable for apple culture and due attention is paid to the details of cultivation. The great point in favour of growing apples on standard trees on grass is that while as good fruit, speaking generally, can be grown under this method as any other, provided conditions are suitable, the cost of production is reduced to a minimum, and this is a very important item in these days.

Mistakes to be avoided.

In planting an orchard the present day farmer should seek to avoid the mistakes made by his forebears, perhaps unavoidably. One is that of having too many varieties—in some of the old orchards there are nearly as many varieties as there are trees. It should be remembered that the great thing in selling fruit is to be able to offer a quantity of one variety. In the old orchards, too, we can see evidence of the importance of studying the growing habit of the varieties planted. Here, for instance, is a big spreading tree capable of bearing a ton of apples, and next to it is another, planted at the same time, that is not one quarter the size. The difference is that one has a vigorous growing habit and the other lacks this. The deduction from this is that only varieties of apples that have capacity for developing into big trees should be planted in grass orchards, and illustrations of these are Bramley's seedling (perhaps the best orchard apple grown), Newton Wonder, Blenheim Orange, New Bess

Pool, and Lord Derby, to which the names of others may be added to suit varying conditions.

It should be remembered that the grazing in an orchard is valuable as well as the fruit. In fact, the grazing may be said to pay the rent of the land; therefore the trees should not be hopelessly overcrowded as they are in so many orchards, because this not only prevents the admission of light and air to the trees but it is impossible to grow sweet, good herbage between and underneath the trees. As a matter of fact, thirty feet between orchard standards is the minimum distance, and in the case of apples like Bramley's seedling, thirty-six feet is better. It is unfortunate that many people fail to conceive the difference between a young tree when it is planted and a fully grown specimen, hence the state of overcrowding in so many orchards.

The Planting of Young Trees.

It is sound advice in planting an orchard never to buy small, weakly trees, because they are dear whatever the price paid for them. An orchard standard should have a straight, clean stem not less than six feet in height, and be furnished with a well balanced head. Good nurserymen can offer trees of this type, and the best way is to select them in the nursery while the leaves are on them and ahead of the time of planting. Generally speaking, the conditions are best for planting from the middle of November to the end of the year, and care should be taken that the roots of the trees are not allowed to get dry before planting commences. When planting trees in grass the turf should first be taken off in a circle four to five feet in diameter and placed on one side. A spit of soil to the depth of one foot should then be taken out, and the sub-soil loosened in the bottom but not removed. The turf should then be cut up and placed in the bottom of the hole, and the tree planted to the depth of the soil mark on the stem. The soil should be evenly and firmly treaded round the tree and all used, even if this means a mound at first, as this will sink as the soil settles. When planting is finished there is a space of two to three feet from the stem with no grass on it, and it is important that this be kept cultivated by means of periodical hoeing for the first few years, but when the tree has got firmly established the grass may be allowed to grow up to the stem.

Staking and Protecting.

Many pounds have been wasted in planting trees in orchards without protecting them properly against live stock. Big cattle and horses should not be allowed to graze in a young orchard, and in all

cases the trees should be properly staked and protected. One method is to use a single stake eight feet long, $2\frac{1}{2}$ x $2\frac{1}{2}$ in., creosoted and sharpened at one end. The stake should be driven in after the hole has been made and before the tree is planted. The stem of the tree should be up against the sawn face of the stake, and for fastening purposes I know of nothing better than old cycle tyres cut in lengths, passed round the stem and crossed over like the figure 8, and fastened to the stake with flat-headed nails. To protect the tree a strong gauged wire netting two feet wide should be used. Six feet lengths should be cut off for the guards, which are fastened to the stake with small staples, and, to prevent animals rubbing, a piece of barbed wire should be hooked into the bottom of the guard and wound tightly round the latter, corkscrew fashion, and hooked at the top. This is probably the cheapest way of protecting trees that will serve the purpose. Another method which has some advantages over the above is to put in three stout posts a few feet from the tree, joined by flat rails or barbed wire sufficiently close to prevent an animal putting its head through. This method allows for easy access to the tree, but it is advisable to put wire netting round the stem as a safeguard against rabbits. It may be added that it is almost a waste of time and money to plant trees in grass orchards unless they are properly staked and protected. Whatever the actual method adopted may be, it is essential that sound material should be used and that the guard should be securely fixed.

Pruning.

The first business of a newly planted tree is to grow, and it should be pruned with this object. When trees are planted the only pruning necessary is the removal of any misplaced twigs, but the leading shoots should be left intact until a year later, and then in the spring, before growth commences, these shoots should be cut back to about one third their original length. The effect of this pruning is to form a good head to the tree by multiplying the shoots and starting the formation of branches. If the tree is not well furnished the leading shoots may be shortened again the next season, and, generally speaking, no further cutting back is necessary, all the pruning that is required being the judicious thinning of the branches to prevent overcrowding. This work, however, should be done systematically and as required, instead of neglecting it, as is frequently the case, until the trees are hopelessly thick, when the pruning necessary not only entails considerable labour but is too drastic for the welfare of the trees.

The Renovation of Orchards.

While the foregoing remarks apply in the main to the planting and management of new orchards, it is highly important that old orchards should be renovated (if only for the reason that they are often situated close to the farmstead and in convenient places). This renovation consists of planting young trees to fill up gaps and cutting back and head-grafting inferior varieties, say, with Bramley's seedling, provided the stems of the trees are sound and are still in vigorous health.

In conclusion, if apples are worth growing in grass orchards attached to farms—and there is plenty of evidence to prove that they are—it is only fair to bestow on the orchard the same care and attention that are given to other sections of the holding. It is useless to plant fruit trees unless the grower is prepared to look after them.

SPRING CABBAGE VARIETY TRIALS AT TALACRE ABBEY MARKET GARDENS, PRESTATYN, 1924—25.

By H. L. Jones, N.D.H.,

Horticultural Superintendent for Flintshire.

Owing to the difficulty experienced by market growers in this district of deciding which of the many varieties of spring cabbage are likely to give the best returns, six of the varieties most commonly grown in the district were sown on two dates, viz., July 25th, 1924, and August 11th, 1924. Eventually it was found that the later sowings were not quite suitable for planting out and it was decided, therefore, to plant the earlier sowings only. They were planted out in their permanent quarters on September 23rd and 24th. The land, which had carried a crop of potatoes, was not specially prepared, and, apart from the application of basic slag at the rate of 3 cwt. to the acre, raked in when the plots were levelled, was unmanured.

The six varieties in the trial were the following:—

No. 1.—Sutton's "Flower of Spring."
No. 2.—Sutton's "April."
No. 3.—Clucas' "Early Market."
No. 4.—Clucas' "Earliest of All."
No. 5.—Webb's "Harbinger."
No. 6.—Ellam's "Early Dwarf."

All the varieties were obtained from firms specialising in these particular varieties, No. 6 being obtained from Messrs. Barr & Sons, Covent Garden, who are stated to possess the best strain of this well-known old variety. Two hundred plants of each variety were planted out under the same conditions.

In March, when the plants had started growing, they were carefully examined for plants that were bolting, with the following result:—

	Percentage of bolted plants.
No. 1	0
No. 2	1
No. 3	0
No. 4	4
No. 5	10
No. 6	4

Application of Nitrate of Soda.

The plots were at the same time cross-dressed with nitrate of soda at the rate of 1 cwt. to the acre. This was so arranged that 100 plants of each variety received nitrate of soda and the same number was left without. The object of this was to demonstrate to growers the advantages of applying such a dressing.

Cutting.

The best prices for spring cabbage are obtained in the seaside markets up to the middle of May. After this time prices drop somewhere about 50 per cent. It was decided amongst the growers themselves that any variety that did not give the maximum of heads fit for cutting before the middle of the month would not be suitable for the purpose of early marketing, and therefore would not give the best financial returns.

Number of each Variety cut by May 16th.

Manured Section.	*Unmanured Section.*
No. 1.—100 % cut by the above date.	No. 1.— 46 % cut by the above date.
No. 2.— 46 % cut by the above date.	No. 2.— 20 % cut by the above date.
No. 3.—100 % cut by the above date.	No. 3.— 32 % cut by the above date.
No. 4.— 58 % cut by the above date.	No. 4.— 19 % cut by the above date.
No. 5.— 20 % cut by the above date.	No. 5.— 3 % cut by the above date.
No. 6.— 37 % cut by the above date.	No. 6.— 15 % cut by the above date.

Conclusions.

The two varieties that proved to be the most suitable under the above conditions were Sutton's "Flower of Spring," an excellent cabbage that gives heads of exquisite flavour and in the manured

section gave plants of very fine size, and Clucas' "Early Market," which proved to be a very good cabbage of excellent flavour, but perhaps not quite as large as the first mentioned.

Comparisons between the same varieties in the dressed or manured sections of each variety afford convincing proof of the advantage of light dressings of a quick-acting nitrogenous fertilizer. Under some conditions, perhaps, sulphate of ammonia would give equally good results, but in this case nitrate of soda was probably the more suitable.

THE BRUCE METHOD OF HONEY PRODUCTION.

By H. L. Jones, N.D.H.,
Horticultural Superintendent for Flintshire.

The Bruce system, it may be explained, is the result of certain experiments carried out in Scotland, the results of which were published in an article in *The Scottish Bee-Keeper* for October, 1924. The article was reprinted in *The Welsh Bee-Keeper* for November of the same year under the title which forms the heading of the present paper. Mr. Bruce claims to have succeeded in obtaining remarkable results and to have been able to exercise absolute control over swarming. His method is as follows:—Two colonies of bees are worked up in spring to their full strength. When the honey flow is assured, hive No. 1 is opened and a comb containing eggs is removed, placed in a restricted brood chamber and supers placed over it. This hive is set on the stand of the colony which produced the eggs. Hive No. 2, standing alongside, is now removed, and so also is hive No. 1, with the result that the new hive receives the flying bees from both colonies. The depleted colonies at once revert to early spring conditions and are treated as such. They are supplied with syrup from a slow feeder so that breeding may be stimulated. These two colonies are gradually returned towards the new hive at the rate of 2ft. per day, so that by the time the original distance between them has thus been traversed, bees are again flying freely. The two hives are once more removed to a distance and the flying bees again join in the queen-less colony. So is the strength of the honey-producing colony maintained. Meanwhile, queen cells are being formed by the honey-producing colony

on the eggs-containing comb which was at the outset introduced. These are removed and another comb substituted. Mr. Bruce claims that in this way there is, in addition to other advantages, an easy production of queen cells, which can be utilised to form nuclei.

Impressed with the possibilities of the method described above, the writer decided to test it in comparison with the methods advocated by present day bee-keepers. Three colonies of bees were devoted to the test, and every effort was made to ensure that all three were of the same strength and strain. Another colony of as far as possible the same strength, and treated as recommended by the most modern of bee-keepers, was used as control. The results of the test are set out below.

The honey flow in this part of North Wales commences about the 15th of June. Two good colonies were stimulated and brought to full strength by that time, and the instructions in the article referred to above were closely followed. The results were very disappointing. The bees in the producing colony seemed to lose heart from the very beginning of the actual experiment. Although queen-cells were formed, were eventually removed, replaced by a comb containing eggs, and the resulting queen-cells again removed, at no time during the honey flow did the bees in the hive work with a will. The result was that they loitered about the entrance in a very undecided mood. Individual bees could often be seen starting out briskly enough, but instead of taking flight, would turn back and re-enter the hive. The hive was throughout the season prominent in having its alighting board covered with bees walking about in an undecided and aimless fashion. At no time did they work with the vim that is characteristic of a queen-right colony. The honey produced from the two colonies united in this manner amounted to less than 40lb., which must be regarded as a very poor result.

The control colony, called No. 4 hive, was treated as follows:—It was stimulated like the other two and on the same date the hive was opened. All combs containing drones were removed, and all the combs that contained larvae and eggs were placed on either flank of the brood chamber. The colony was supered with two shallow framed supers of drawn out comb, and when the top super was partly filled they were raised and an empty super was placed over the excluder. The brood chamber was raised half-an-inch clear of the floor-board all round and the outer cover one inch. This colony, after the bees had taken to the supers, was never without four shallow frame supers over the excluder, and at one time it had, in addition, two brood-chambers over the excluder. The brood-

chamber was carefully examined at intervals, and at no time was a queen-cell found on the combs. The result for the season was a surplus of 180lb. of extracted honey, and enough was left in the hive to dispose of any fear that the colony will be short of food in the spring.

The results of one test are admittedly insufficient to disprove the results which have been claimed for the Bruce method. They were, however, to a great extent, what the writer had anticipated. In all his fairly long experience he has never seen a colony that was queen-less over a prolonged period working with the same determination and efficiency as one that was headed by a good queen. If bee-keepers make sure that they have the right type of queen at the head of their colonies, manage the colonies in such a way that the queen is not crowded out by the bees storing honey in the brood chamber, and they see to it that the colony is not distressed for want of air, they will experience less trouble with swarming.

Bee-keeping is making great strides in North Wales owing mainly to the encouragement given to it by the Ministry of Agriculture, and at the moment there would seem to be every prospect for a substantial increase in the number of bee-keepers.

SOME EXPERIMENTS ON THE CONTROL OF BUNT IN WHEAT BY COPPER CARBONATE AND OTHER CHEMICALS, INCLUDING DATA ON THE GROWTH AND YIELD OF TREATED AND UNTREATED GRAIN.

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I. Introduction.

Bunt, a disease caused by the two fungi *Tilletia tritici* and *Tilletia laevis*, is one of the most abundant and widespread diseases of wheat. The occurrence of bunt (*Tilletia tritici*) in this country is indicated by the following figures recently published in the Annual Report of the Official Seed Testing Station for England and Wales (1).

Year.	Number of Wheat samples found by naked eye examination to be contaminated by bunt spores.
1921—22	33 per cent.
1922—23	15.7 per cent.
1923—24	16.0 per cent.

These figures suggest either that current methods of control are for some reason unsatisfactory, or that farmers in the British Isles are not aware of the extensive losses bunt may cause in the wheat crop.

Two methods of treating wheat for bunt are in use at the present time in this country:—(1) the copper sulphate dip, (2) the use of formalin solution, either as a dip or a spray. Both methods involve the use of water and the subsequent drying of the grain. With both it is necessary to use accurately made up solutions, since seed injury follows the application of solutions above a certain strength. In both cases it is necessary to sow the grain shortly after treatment, adjusting the drill to allow for swollen grain, or to dry the grain thoroughly before storing it in bags to avoid "heating" or other injury which might effect the germination of the seed.

It is evident, therefore, that a dry method of treating grain would have certain obvious advantages over the two wet treatments now in use.

1. A dry treatment would be less troublesome to carry out since no solutions of correct strength need be made up.
2. Dry treated grain would be more convenient to handle and the drill need not be adjusted to allow for swollen grain.
3. A dry treatment could be carried out any time between harvest and sowing, and the grain could be sown on the same day or stand for a long period without danger of lowering the germination capacity of the seed.

The problem is, therefore, to find a cheap powder which will adhere readily to the grain, give adequate control of the disease and have no injurious effect on either the germination of the seed or the subsequent growth of the plant.

During the last eight years experiments have been carried out in various countries with different chemicals in the form of a fine powder. The published results of this work were briefly reviewed

in the first volume of this Journal (20). The most extensive experiments have been made with compounds of copper, and the best results have been obtained with powders containing copper in the form of carbonate.

In the past year results have been published of further experiments with dry fungicides conducted in Denmark (6), United States of America (3, 8), New Zealand (15), and Australia (14). In each case copper carbonate is reported to have given satisfactory control of bunt. Barss (3) and Hungerford (8) both record the fact that brands of copper carbonate containing 50 per cent. or more of copper gave more effective control when applied at the rate of two ounces per bushel of grain than cheaper brands applied at the same rate containing only about 20 per cent. copper. The control given by these lower grades was, however, more efficient when they were applied to the grain at a higher rate. No writer has claimed that even the best grades of copper carbonate completely eliminate bunt from very badly contaminated samples of grain. In such cases formalin (one part in 320 parts water) gives better results as far as the elimination of bunt is concerned (14).

During more recent years experiments have been made also with organic mercury compounds in powder form. Barss in Oregon (3) and Hungerford in Northern Idaho (8) report good control of bunt with "semesan," an organic mercury compound manufactured by E. J. Du Pont de Nemours and Co., Wilmington, Delaware, U.S.A. In New Zealand "semesan," applied both dry and as a steep, gave slightly better results than copper carbonate, eliminating bunt completely in one experiment where the untreated rows contained 30 per cent. bunted heads. The copper carbonate treated rows yielded .5 per cent. bunt in the same experiment (15).

In Germany (13), on the other hand, copper carbonate is reported as an unsatisfactory fungicide for bunt in wheat. In one case, when used at the rate of 2 gm. per 1 kg. of grain, the disease was only reduced from 65.3 per cent. (untreated) to 37.6 per cent. (treated). The same series of experiments include, however, tests with certain organic compounds in powder form, the chemical composition of which is not given, which gave excellent control of bunt, entirely controlling it in some cases. It is interesting to find that the same compounds were also effective when applied for the control of smut in oats, a disease for the control of which the copper dust method of treatment has not always been found satisfactory.

A dry method of treating seed wheat has been tested in Hungary (11) and there excellent results were obtained with two proprietary

preparations designated " porzol " I and II. These are said to have given far more satisfactory results both in regard to bunt control and general vigour of the plant than either copper sulphate or formaldehyde.

It appears from the trend of recent experiments as if a dry powder treatment for bunt of wheat might shortly supersede the use of formalin and copper sulphate solution, and perhaps also supersede the more recently introduced steeps " germisan " and " uspulun." The effect of a treatment on the percentage disease in a crop is not, however, the only point to be considered in making the choice between several fungicides. Copper sulphate and formalin are being discarded largely owing to their deleterious effect on the germination of the grain under certain conditions. In the following series of five experiments, extending over a period of three seasons, a number of copper dusts have been tested in regard to both their control of bunt and their influence on the growth and final yield of the crop. The general result seems to be decidedly in favour of the use of copper dusts. Good control of bunt was given, a better stand resulted in the field from the treated lots, more heads were produced per row at harvest, and a remarkably high increase in the yield of healthy grain followed the application of copper dusts.

II. Scheme of Experiments for the Control of Bunt in Wheat.

The results are given in the present paper of five experiments carried out in the seasons 1923-25. The general plan of the experiments was as follows:—The bulk of grain from a crop badly attacked by bunt was in each experiment divided into a number of equal portions, one of which was put aside for the control while the others were subject to various treatments. Samples of the treated lots were taken and sown in rows in the field, a uniform rate of seeding being adopted throughout one experiment. The weight of grain used in the different experiments, the rate of seeding and the number of replications sown are given below.

Observations on brairding and later growth were made on the field from time to time. At harvest the rows were cut by hand, tied up separately with the ears enclosed in brown paper and hung up to dry. The bundles were finally examined, separated into healthy and bunted ears, and the percentage bunt was calculated for each row. In making this estimation an ear only partially diseased was classed with the bunted heads, but the numbers of such heads was almost negligible in the varieties under test.

In experiments I, III, IV and V healthy tillers from each row were thrashed and the grain yield determined. All figures for grain yield in these tables include healthy grain only.[1]

Experiment I.

Variety.—April Bearded. Ca. 575.

Date and place of sowing.—11th Apr., 1923. Upper Ridge Field.

Weight of grain for each treatment.—4 lb.

Replications.—Five rod rows for each treatment.

Rate of seeding.—600 grain per rod row.

The following methods of treating the grain were tested:—

(1) *Copper Carbonate. Sample A.*—3.5 gm. dry powder per 4 lb. grain (equivalent to 2 oz. per bushel or 4 oz. per cwt.).

(2) *Copper Carbonate A.* in suspension.—3.5 gm. was mixed with enough water to wet 4 lb. of grain. After thorough mixing the grain was spread out to dry.

(3) *Dehydrated Copper Sulphate.*—Copper sulphate crystals were heated at 99°C. for several days until a white or very pale blue powder was obtained. 3.5 gm. of this powder were applied to 4 lb. of grain.

(4) *Dehydrated Copper Sulphate diluted with an equal weight of chalk.* 3.5 gm. of the mixture per 4 lb. grain.

(5) *Bordeaux powder.*—7 gm. per 4 lb. grain.

(6) *Common salt.*—7 gm. per 4 lb. grain.

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1 A slight error is introduced into the figures for grain yield by rejecting bunted heads before thrashing the produce of the separate rows. The magnitude of this error was determined in Experiments III, IV and V by the following method:—Five separate lots of 100 bunted heads taken at random were thrashed and the produce separated into healthy and bunted grain. The healthy grains from each lot were counted and weighed, and the average weight of healthy grain produced in the bunted heads was then calculated for the untreated rows. In these three experiments the weights of healthy grain per row lost by discarding bunted heads before thrashing were respectively 1.38; .26 and 2.73 grammes, giving corresponding percentage errors in the figures for grain yield of 1.12; .16 and 1.30. It is evident that such an error does not materially affect the conclusions drawn from the yield data.

Year.	Experiment.	Variety.	No. of healthy grain from 100 bunted heads.		Weight of healthy grain from 100 bunted heads.	Weight of healthy grain per row rejected with bunted heads.	Percent. error in grain yield data of untreated rows.
			Av.	Range.			
1924	III.	Hen Gymro.	46	12—82	1.44	1.38	1.12
1925	IV.	Hen Gymro.	6	0—13	.24	.26	.16
1925	V.	Standard Red.	40	33—50	1.86	2.73	1.30

(7) *Lime Sulphur spray.*—One part commercial lime sulphur per 75 parts tap water. 10 oz. of the solution was sprayed over 4 lb. grain, which was raked during the operation and then spread out to dry.

(8) *Formalin* (38.79 % formaldehyde).—One part formalin in 320 parts water. 10. oz. solution per 4 lb. grain.

(9) *Formalin.*—One part formalin in 480 parts water. 10 oz. solution per 4 lb. grain.

These solutions (8) and (9) are hereafter referred to as "strong" and "weak" solutions respectively.

The formalin solutions were sprayed over the grain, which was turned repeatedly until it was uniformly moist. It was then covered for four hours with sacks moistened with the solution, and finally spread out in a thin layer to dry.

To apply the dry powders the requisite weight was placed in a fine sieve and scattered over the grain, which was well raked. By this method the grain became completely covered with powder.

After treatment the different lots were stored in new or sterilised bags until samples were weighed for sowing.

Experiment II.

Variety.—Hen Gymro. Two bulks Ca. 583 and Ca. 584.

Date and place of sowing.—11th December, 1923. Gorse Field.

Weight of grain for each treatment.—400 gm., except where stated below.

Replications.—Five rows of six feet for each treatment.

Rate of seeding.—720 grain per row.

This high rate of seeding was not intentional, the grain having been weighed out in sufficient quantity for rod rows. The mistake was perhaps fortunate, however, as the plot was visited by birds and much of the grain was devoured. A reasonably good stand was finally obtained and reliable data were given as to the incidence of bunt, but no attempt was made to collect yield data from this experiment.

The following methods of treating the grain were tested with one or both pure lines:—

(1) *Copper carbonate A.* at the rate of 2 oz. per bushel.

(2) *Cuprite.*

(3) *Dehydrated copper sulphate and chalk,* at the rate of 4 oz. per bushel.

(4) *Copper sulphate solution.* 2.5 %. Grain soaked for ten minutes.

(5) *Formalin.* Strong. One part in 320 parts water.

(6) "*Seedolin.*" At the rate of one pint per four bushels of grain. This method was tested since the belief is apparently not uncommon among farmers in Wales that seedolin, which is employed in the first place as a protection from birds, has the additional effect of controlling Bunt.

(7) "*Uspulun.*" .25 % solution. 1,000 gm. soaked for one hour.

(8) "*Germisan.*" .25 % solution. 1,000 gm. soaked for 40 minutes.

These proprietary substances have been widely tested in Germany (10, 17, 21) and other countries of Europe (5), and are recommended by a number of investigators for the control of bunt in wheat as well as for various other seed-borne diseases. Both "uspulun" and "germisan" contain organic mercury salts and have the disadvantage of being extremely poisonous.

(9) *Soaked in tap water.* This treatment was introduced for comparison with the lots treated with "Uspulun" and "Germisan" and copper sulphate solution. These solutions became dark with spores and the beneficial result following the use of these substances was no doubt partly due to the fact that a large number of spores were poured off after each steeping.

Experiment III.

Variety.—Hen Gymro. Ca. 583.

Date and place of sowing.—18th February, 1924. Gorse Field.

Weight of grain for each treatment.—2 lb.

Replications.—Eight rod rows for each treated lot; eighteen rod rows for the control.

Rate of seeding.—500 grain per rod row.

The following methods of treating the grain were tested, the details of treatment being the same as in Experiments I and II.

(1)—(6) *Copper Carbonate.* Six different samples containing different percentages of copper and varying in density.

(7) *Dehydrated Copper Sulphate.*

(8) *Dehydrated Copper Sulphate and Chalk.*

(9) *Cuprite.*

(10) *Formalin.* One part in 320. Grain sown two days after treatment.

(11) *Formalin.* One part in 320. Grain sown one week after treatment.

(12) *Formalin.* One part in 480. Grain sown two days after treatment.

(13) *Formalin.* One part in 480. Grain sown one week after treatment.

(14) *Uspulun.*

(15) *Germisan.*

(16) *Soaked in tap water.*

Experiment IV.

Variety.—Hen Gymro. Pure lines 209 and 219.

Date and place of sowing.—25th October, 1924. Hazel Field.

Replications.—Ten rod rows.

Rate of seeding.—500 grain per row.

Half of each bunted sample was treated by shaking in a tin with a weighed quantity of copper carbonate A (two ounces per bushel). Samples of treated and untreated grain were then weighed out for sowing. Five of the treated lots were "after-contaminated" by re-turning the grain to envelopes which had contained badly bunted

grain and were black with spores. The copper carbonate did not entirely protect the grain from the effects of re-contamination (Table IV).

EXPERIMENT V.

Variety.—Standard Red. Ca. 595.

Date and place of sowing.—3rd November, 1924. Hazel Field.

Weight of grain for each treatment.—500 grammes.

Replications.—Untreated seventeen; four or eight for each treated lot (see Table V).

Rate of seeding.—960 grain per row.

The high rate of seeding was adopted in view of the late date of sowing.

The following methods of treating the grain were tested, the details of treatment being the same as in Experiments I—III.

(1) *Formalin* (39.43 % formaldehyde): One part in 480.[2]
(2) *Flowers of Sulphur*: 19 gm. per 500 gm. of seed.
(3) *Potassium permanganate*: .5 % solution. Grain soaked 24 hours and then dried. 500 gm. of grain per 2,000 c.c. solution.
(4) *Dehydrated Copper Sulphate.*
(5) *Copper dust B* containing 49.93 % copper.
(6) *Copper dust C* containing 49.85 % copper.
(7) *Copper dust D* containing 25.41 % copper.
(8) *Copper dust E* containing 9.72 % copper.

Dehydrated copper sulphate and the four *copper dusts B—E* were each applied at the rate of 2 oz. and 4 oz. per bushel of wheat.

III. Discussion of Results.

(a) THE EFFECT OF THE DIFFERENT TREATMENTS ON THE PERCENTAGE BUNT.

In *Experiment I* (Table I), in which April Bearded wheat was sown on 11th April, 1923, the amount of disease in the untreated sample was only 10 per cent. Complete control was in this experiment given by both the stronger formalin solution and by dehydrated copper sulphate. The weaker formalin and dry copper carbonate also gave good control, the disease being reduced by these treatments to 0.15 per cent. and 0.18 per cent. respectively. Two other dry treatments, a proprietary Bordeaux mixture, and dehydrated copper sulphate diluted with chalk, reduced the disease to under 1 per cent. Lime sulphur spray and salt, although not satisfactory, caused about 50 per cent. reduction in the amount of bunt.

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2 The writers are greatly indebted to Dr. Wm. Goodwin, Advisory and Research Chemist of the South Eastern Agricultural College, Wye, for analyses of this and other samples of formalin.

The results of the experiments are set out in Tables I—V.

TABLE I.

Variety:—April Bearded, Ca. 575. Date and Place of Sowing:—11th April, 1923, Upper Ridge Field. Replications:—5 rod rows.

Ref.	Treatment.	Germination. 5 days.	Germination. 10 days.	Brairding. 2/5/23. Max. 5.	Av. no. of tillers per row at harvest.	Av. yield of grain in grammes.	Av. yield of grain in terms of untreated at 100.	Av. yield of straw plus grain in grammes.	Percent. Bunted ears.
1.	Untreated ...	50	92	4.2	221	(1) 158 ± 10.0	100	(1) 698	10.44
2.	Lime Sulphur spray ..	73	93	4.4	281	196 ± 2.9	124	750	4.19
3.	Salt ...	55	92	4.2	277	198 ± 10.4	125	736	3.96
4.	Bordeaux powder ..	57	89	4.3	283	215 ± 13.3	136	770	0.84
5.	Dehydrated copper sulphate + chalk ...	60	92	4.5	324	220 ± 8.9	140	804	0.69
6.	Copper carbonate suspension in water ...	76	94	4.4	302	200 ± 9.5	126	756	0.34
7.	Dry copper carbonate Sample A. ...	62	93	4.4	325	(3) —	—	(3) —	0.18
8.	Formalin. 1:480 ...	72	90	3.8	321	(1) 265 ± 6.3	168	(1) 830	0.15
9.	Formalin. 1:320 ...	20	74	2.1	199	(2) 156	99	(2) 566	0.00
10.	Dehydrated copper sulphate	66	96	4.7	329	225 ± 5.8	142	822	0.00
	Average dry copper dusts (4, 5 and 10) ...	61	93	4.5	312	220 ± 5.3	139	799	0.51

(1) Two lots attacked by mice, weights based on three replications only.
(2) Four lots attacked by mice, weights based on one replication only.
(3) Five lots attacked by mice, no weight data obtained.

Since the produce of each row was tied up separately with the heads encased in brown paper, it was possible to detect which bundles had been at all damaged by mice and to exclude these from the results of final yield. It was, however, possible to separate such bundles into healthy and bunted ears and the figures in the above table giving the percentage of bunt and the average number of tillers per row are based in all cases on five replications.

TABLE II.

Variety:—Hen Gymro, Ca 583 and Ca 584.   Date and place of Sowing:—11th December, 1923, Gorse Field.

Replications:—Five for each treatment, 6 foot rows.

Treatment.	Ca 583.				Ca 584.				Percent. Bunt.
	Germination.		Av. no. of tillers per row at harvest.	Percent. Bunted ears.	Germination.		Av. no. of tillers per row at harvest.	Percent. Bunted ears.	Aver. of the two pure lines.
	5 days.	10 days.			5 days.	10 days.			
1. Untreated ...	64	86	156	38.0	80	91	99	41.1	39.5
2. "Seedolin" ..	35	78	118	43.6	43	89	76	46.0	44.5
3. Soaked in tap water	63	39	123	22.1	—	—	—	—	22.1
4. "Cuprite" ...	73	95	155	13.9	76	90	98	5.9	9.9
5. Dehydrated copper sulphate plus chalk	74	96	159	12.4	82	90	67	5.1	8.8
6. Formalin. One part in 320 parts water	66	92	167	7.4	76	92	93	5.3	6.3
7. "Germisan" ...	51	87	154	5.0	—	—	—	—	5.0
8. Copper sulphate solution ...	62	88	123	3.4	78	93	103	3.6	3.5
9. Copper carbonate Sample A ...	76	94	132	2.4	76	90	108	4.3	3.3
10. "Uspulun" ...	55	90	147	2.0	—	—	—	—	2.0

TABLE III.

Variety:—Hen Gymro, Ca 583. Date and place of sowing:—18th February, 1924, Gorse Field.
Replications:—Eighteen rod rows of untreated grain, eight rod rows of each treated lot.

Treatment.	Germination.		Av. no. of tillers per row.	Av. yield straw and grain per row. Grammes.	Av. grain yield per row in grammes.	Av. grain yield per row in terms of untreated at 100.	Percent. Bunted ears.
	5 days.	10 days.					
1. Untreated ...	58	90	274	698	123 ± 4.1	100	35.09
2. Soaked in tap water ...	36	81	294	765	159 ± 8.2	130	17.85
Copper dusts.							
3 "Cuprite" ...	10	91	251	687	168 ± 11.3	137	5.44
4. Dehydrated copper sulphate and chalk ...	58	93	254	714	168 ± 7.7	137	4.39
5. Dehydrated copper sulphate alone ...	34	90	261	751	213 ± 15.4	174	1.73
6. Copper carbonate No. 13500 ...	54	86	252	699	172 ± 11.8	141	3.96
7. Copper carbonate No. 13671 ...	45	90	289	806	200 ± 10.9	163	2.48
8. Copper carbonate No. 13130 ..	35	89	256	705	181 ± 11.8	148	2.18
9. Copper carbonate No. 13670 ...	44	87	261	734	186 ± 8 2	152	2.10
10. Copper carbonate No. 13669 ...	38	89	247	671	168 ± 10.0	137	1.55
11. Copper carbonate Sample A ..	41	90	295	803	213 ± 10.9	174	1.14
Average for copper dusts ..	43	87	263	730	186 ± 3.6	150	2.77
Formalin solutions.							
12. 1:480 sown two days after treatment ...	—	—	240	674	159 ± 6.4	130	1.87
13. 1:480 sown one week after treatment ..	43	87	260	710	181 ± 8.6	148	2.26
14. 1:320 sown two days after treatment ...	—	—	269	778	191 ± 9.1	156	2.15
15. 1:320 sown one week after treatment ...	33	86	251	689	177 ± 10.9	144	1.92
Average for Formalin ..	38	87	255	713	177 ± 4.5	145	2.05
15 "Uspulun" ...	50	90	284	775	195 ± 8.2	159	1.70
17. "Germisan" ...	23	90	295	840	204 ± 10.4	167	1.59

TABLE IV.

Variety:—Hen Gymro, Pure Lines 209 Ca and 219 Ca. Date and Place of Sowing:—25th October, 1924, Hazel Field. Replications:—10 rod rows.

Treatment.	No. of replications.	209 Ca. Growth in field. 29/4/25. Max. 5.	209 Ca. Av. no. of tillers per row at harvest.	209 Ca. Av. yield of grain per row in grammes.	209 Ca. Av. yield of grain per row in terms of untreated at 100.	209 Ca. Percent. bunted tillers.	219 Ca. Growth in field. 29/4/25. Max. 5.	219 Ca. Av. no. of tillers per row at harvest.	219 Ca. Av. yield of grain per row in grammes.	219 Ca. Av. yield of grain per row in terms of untreated at 100.	219 Ca. Percent. bunted tillers.
1. Untreated. ...	10	2.9	276	163 ± 4.5	100	39.3	2.7	289	196 ± 4.5	100	42.3
2. Treated copper carbonate; returned to clean envelopes ...	5	3.8	367	424	260	1.2	3.5	358	394	201	0.9
3. Treated copper carbonate; returned to contaminated en-envelopes ...	5	3.4	352	377	231	5.2	3.7	359	433	221	4.1
Average treated lots ...	10	3.6	359	400 ± 14.1	245	3.2	3.6	359	413 ± 10.0	211	2.5

TABLE V.

Variety:—Standard Red, Ca 595. Date and Place of Sowing:—3rd November, 1924, Hazel Field.

Treatment.	No. of replications.	Germination.		Growth in Field.		Av. no. of tillers per row at harvest.	Av. yld. per row. Grain + straw. Grammes.	Av. yield per row. Grain only. Grammes.	Av. yld. of grain in terms of untreated at 100.	Percent. bunted tillers.
		5 days.	10 days.	9/1/25 Max. 5.	17/3/25 Max. 5.					
1. Untreated ...	17	81*	91*	3.9	4.4	354	825	210 ± 6.37	100	41.4
2. Flowers of sulphur ...	8	85*	92*	3.8	4.3	366	942	312 ± 6.72	149	29.1
3. Potassium Permanganate ...	8	74*	90*	4.1	4.4	388	958	347 ± 11.9	165	18.7
4. Formalin 1:480 ...	8	—	—	3.9	4.4	380	1011	386 ± 8.93	182	11.4
Copper dusts.										
5. D. 25.41 % copper 2 oz. ...	4	91	96	3.8	4.5	391	1029	383	184	18.3
6. E. 9.72 % copper 2 oz. ...	4	90	95	4.3	4.8	407	1015	376	179	10.8
7. C. 49.85 % copper 2 oz. ...	4	—	—	5.0	5.0	643	1371	533	254	4.3
8. E. 9.72 % copper 4 oz. ...	4	88	94	4.6	4.8	467	1113	450	214	3.8
9. D. 25.41 % copper 4 oz. ...	4	90	96	4.8	4.8	473	1201	501	239	2.4
10. Dehydrated copper sulphate 2 oz. ...	4	82	94	4.9	5.0	641	1188	482	229	2.3
11. B. 49.93 % copper 2 oz. ...	4	89	97	4.5	4.9	460	1129	457	218	2.1
12. C. 49.85 % copper 4 oz. ...	4	89	96	4.8	5.0	567	1136	468	223	1.2
13. B. 49.93 % copper 4 oz. ...	4	92	95	5.0	4.9	642	1394	573	273	1.1
14. Dehydrated copper sulphate 4 oz. ...	4	78	90	4.6	5.0	576	1178	482	229	).9
Average eight dust treatments (7—14), each of which has reduced bunt to 4.3 % or under ...	32	87	95	4.8	4.9	559	1204	487 ± 8.07	232	2.3

* Figures based on average of 600 grain tested in lots of 100. Other figures based on 300 grain.

Experiment II. The two bulks of Hen Gymro used in this experiment gave very similar results, the one showing 38 per cent. bunt in the untreated lot, and the other 41.1 per cent. (Table II). The disease was not completely controlled by any treatment, the best result, 2 per cent., being given by "uspulun." Good control was given in each case by copper carbonate A, the disease being reduced from 39.5 per cent. to 3.3 per cent., taking the average results of the two tests. The stronger formalin was not in this experiment quite so effective, the average result being 6.3 per cent. Two other copper dusts, "cuprite" and dehydrated copper sulphate plus chalk, only reduced the disease to 9.9 and 8.8 per cent. respectively. It is interesting to note that soaking the grain in water and thereby removing a large number of the bunt spores adherent to the grain had the effect of reducing the disease from 38 per cent. to 22.1 per cent.

"Seedolin" has not only failed to control the disease, but appears in each case to have increased it. It is possible that this increase in the percentage bunt in the "seedolin" treated samples might be related to their slower germination, which would conceivably admit of a longer period over which infection could take place. Evidence of the slower germination of the "seedolin" treated lots was given by the laboratory tests, the germination at five days being 35 and 43 as compared with 64 and 80 for the untreated samples.

Apart from the failure of "seedolin" to control bunt, it gave in this experiment no protection from birds. Observations in the field showed that grain treated with "seedolin" was as eagerly attacked by birds as any of the other lots, and it is significant that the "seedolin" rows gave in one case the lowest, and in the other case the second lowest, figure for the average number of tillers per row at harvest (Table II).

Experiment III. For this experiment one of the bulks of Hen Gymro used in the last experiment was sown again on 18th February, 1924, fresh samples of grain being treated.

A high percentage of bunt (35.09 per cent.) was again obtained and no treatment gave complete control. The lowest percentage of disease, 1.14 per cent., was obtained from grain treated with copper carbonate A. "Uspulun," "germisan," formalin weak and strong, dehydrated copper sulphate and four other samples of copper carbonate reduced the disease to approximately 2 per cent. Cuprite and dehydrated copper sulphate diluted with chalk, although reducing the disease considerably (5 per cent. and 4 per cent. respectively), were less effective than the treatments above mentioned.

Soaking the grain in tap water again reduced the disease by about 50 per cent.

Experiment IV. The copper carbonate treatment reduced the disease in this experiment from 39.3 to 1.2 per cent. and from 42.3 to .9 per cent. respectively in the two pure lines under test. Where the grain was re-contaminated after treatment the corresponding figures were 5.2 and 4.1 per cent., showing that copper carbonate is not an absolute insurance against infection resulting from contamination after treatment. The "after-contamination" was, however, in this case particularly heavy, since only small lots of the treated grain were placed in envelopes black with spores of the fungus.

Experiment V. The untreated rows yielded in this experiment 41.4 per cent. bunted heads. The disease was reduced by both flowers of sulphur (29.1 per cent.) and potassium permanganate (18.7 per cent.). The weaker formalin solution was relatively less satisfactory in this experiment, giving 11.4 per cent. bunt. Two proprietary copper dusts, D and E, containing respectively 25.41 and 9.72 per cent. copper, were also unsatisfactory when applied at the rate of two ounces per bushel, giving 18.3 and 10.8 per cent. bunt; but applied at the rate of four ounces per bushel better control was given, the figures in this case being 2.4 and 3.8 per cent. Dehydrated copper sulphate and two copper dusts, B and C, each containing about 50 per cent. copper, gave good control with both rates of application, but in each case the higher rate of dressing gave a slightly better result. No treatment completely eliminated bunt. The lowest figure, .9 per cent., was obtained with dehydrated copper sulphate applied at the rate of four ounces per bushel of wheat.

Summary of the Five Experiments.

Summarising the results of the five experiments, it is evident that the most effective control of bunt was given by formalin, "uspulun," "germisan," dehydrated copper sulphate and the higher grade samples of copper carbonate. The results of these treatments are, therefore, summarised in Table VI.

It is of interest to notice that where the percentage of disease is high in untreated lots, none of the treatments under test gave perfect control (Tables I-V), but when the percentage of bunt in the control was only ten, the stronger formalin solution and one of the copper dusts, completely eliminated the disease (Table I).

In Experiments I and III, where formalin was used in two concentrations, there appears to be but little difference in the control given by the strong and the weak solutions, thus confirming the results

obtained by Salmon and Wormald (18), but in Experiment V, where only the weaker solution was tested, the control given by formalin is not satisfactory.

TABLE VI.

Results of the treatments which gave the best control of bunt in five experiments.

Experiment.	I. 1923.	II. 1924.	III. 1924.	IV. 1925.	V. 1925.
Treatment.	Spring sown. % bunt.	Autumn sown. % bunt.	Autumn sown. % bunt.	Autumn sown. % bunt.	Autumn sown. % bunt.
Untreated	10.44	39.5	35.09	40.8	41.4
Dehydrated copper sulphate	0.00	—	1.73	—	2.3
Copper carbonate A.	0.18	3.3	1.14	1.05	—
Copper dust B.	—	—	—	—	2.1
Formalin 1:480	0.15	—	2.07	—	11.4
Formalin 1:320	0.00	6.3	2.04	—	—
"Uspulun"	—	2.0	1.70	—	—
"Germisan"	—	5.0	1.59	—	—

Comparison of the Different Copper Dusts.

Since the main object of these experiments was to test the efficiency of the dry powder treatments a number of different copper dusts was used. It is evident from Table VI that the better grades of copper carbonate have given on the whole slightly better control than formalin, but it is also clear from Experiments III and V that different grades of copper carbonate are not equally effective, a fact which has been fully demonstrated by Mackie and Briggs (12) and other workers in America (3, 4, 7, 8).

The copper dusts used in Experiments III and V are compared in Table VII in regard to the percentage copper they contain, their density as indicated by the weight of a cubic inch of the powder in grammes, and their control of bunt. It is evident from both experiments that dusts containing a high percentage (47-54) of copper are slightly more effective than those which contain a lower percentage, but in both experiments very good control was given by dehydrated copper sulphate containing only 31.12 per cent. copper. It is interesting to find that a dust containing only 9.72 per cent. copper gave relatively good control of bunt when applied at the rate of four ounces per bushel (dust E, Experiment V). These data support the conclusions of various workers in America who find that

the best grades of copper carbonate containing over 50 per cent. copper are slightly more effective than the cheaper grades containing about 21 per cent. (3, 8, 12). In these experiments the control of bunt seems to be more closely related to the copper content of a dust than to its density.

TABLE VII.

Relative value of dusts containing different percentages of copper and varying in density.

Dust.	Per cent. copper.	Wt. per cubic inch in grammes.	Per cent. bunted heads.	
			Dust at 4 oz. per bushel.	Dust at 2 oz. per bushel.
1924 *Experiment.*				
Untreated ...	—	—	—	35.09
Copper carbonate A.	54.26	7.0	—	1.14
Copper carbonate 13669	50.2 *	6.87*	—	1.55
Copper carbonate 13670	53.4 *	6.0 *	—	2.10
Copper carbonate 13130	47.0 *	13.0 *	—	2.18
Copper carbonate 13671	51.3 *	8.83*	—	2.48
Corona copper carbonate 13500	21.5 *	6.8 *	—	3.96
Dehydrated copper sulphate	31.12	12.0	—	1.95
Cuprite ...	39.56	12.0	—	5.43
1925 *Experiment.*				
Untreated ...	—	—	41.4	41.4
Proprietary dust B. ...	49.93	12.9	1.1	2.1
Proprietary dust C. ...	49.85	9.3	1.2	4.3
Proprietary dust D. ...	25.41	3.1	2.4	18.3
Proprietary dust E. ...	9.72	12.3	3.8	10.8
Dehydrated copper sulphate	31.12	12.0	.9	2.3

* The writers are indebted for these figures to Professor Barss, Oregon Agricultural College, Corvallis, by whom these samples were originally sent. The writers received the samples from Dr. Pethybridge, Harpenden, to whom thanks are cordially given. The copper estimations in other dusts were made by Mr. T. W. Fagan, Independent Lecturer in Agricultural Chemistry, whose help the writers gratefully acknowledge.

Before leaving the question of bunt control reference might be made to the value of the dust treatment for small lots of grain required for experimental work. In 1923 over 300 small packets of seed wheat, much of which was badly bunt-contaminated, were shaken up individually with copper carbonate before sowing. The resulting rows were found at harvest to be practically free from bunt, although others not so treated, growing in the same field (but sown three weeks later), were badly attacked.

(*b*) The Effect of Treatment on Germination, Growth and Yield.

(1) *Laboratory germination tests on sand.*

Considering the effect of the various treatments as indicated by a laboratory germination test on sand (Tables I, II, III and V) it

should be stated that, owing to the large number of samples involved and the desirability of putting all to germinate on the same day, it was only possible in most cases to test three separate lots of 100 seed from each sample. This number is not considered sufficient for reliance to be placed on differences in the energy results (five days germination) unless they are large and confirmed by the total germination figures (ten days). In these experiments, therefore, with the exception of "seedolin" (Experiment II), the only treatment which can definitely be said to have markedly depressed both the energy of and the total germination is the stronger formalin solution in Experiment I. These figures were confirmed by a second germination test, and the effect of the treatment was again evident when the rows were marked for brairding about three weeks after the grain was sown. Every row treated with this substance appeared to be thinner, and the individual plants were less vigorous in comparison with the control and the other treated lots. Those treated with the weaker formalin solution were perhaps slightly inferior to the control on this date, but this inferiority was soon lost and these rows were finally among the best in this experiment. The effect of the stronger formalin solution, on the other hand, lasted until maturity, but, unfortunately, no reliance can be placed on the figure for grain yield for this lot since it is based on only one row.

A similar adverse effect with formalin solution of this strength was obtained in 1922 on the same variety, April Bearded (19). No adverse effect was, however, apparent in either Experiments II or III in which Hen Gymro was the variety tested. It is not known whether this difference is actually due to the variety or to different conditions either at the time of treatment or at the time of sowing.[3]

Neill has recently recorded the fact that new seed and yearling seed of the same variety varied in their response to formalin treatment. Using a 1 in 320 solution the new seed sustained little damage even after holding for three weeks before sowing, while the yearling seed showed a 5 per cent. loss in germination when tested immediately and this increased steadily to 26 per cent. loss at the end of three weeks (16).

Hurd showed that the extent of formalin injury to wheat varies with the conditions under which the grain is dried or stored after treatment (9). There is, therefore, an element of uncertainty in the formalin method of controlling bunt which makes it the more

[3] Baker (2) testing over a period of one year six varieties of wheat treated with formalin solution 1:400, reports that the germination, as indicated by a laboratory test on filter paper, was not lowered by the treatment. A formalin solution of this strength is found to give satisfactory control of bunt in S. Africa.

desirable that the dust method be thoroughly tested in regard both to bunt control and to the effect on growth and yield.

The effect of the copper dust treatment on the germination of the grain as determined by laboratory tests is seen in Table VIII, in which the figures for the different dusts have been averaged in each experiment.

TABLE VIII.

Germination in sand of lots treated with copper dusts compared with that of untreated grain.

Experiment.	I.		II.		II.		III.		V.	
Variety.	April Bearded.		Hen Gymro 583.		Hen Gymro 584.		Hen Gymro.		Stand. Red.	
Time.	5 days.	10 days.	5 days.	10 days.	5 days.	10 days.	5 days.	10 days.	5 days.	10 days.
Untreated	50	92	64	86	80	91	58	90	81	91
Treated	61	92	74	95	78	90	43	87	87	95

In the case of April Bearded, Standard Red and Hen Gymro 583 (Experiments I, II and V) there appears to be a difference in favour of the lots treated with copper dusts, whereas in Experiment III the difference is in favour of the untreated grain. Further data on this point are desirable.

(2) *Germination and Growth in the Field.*

In the trials under review no counts were made during growth in the field, but marks (maximum 5) were given for brairding and vigour of growth in Experiments I, IV and V. In Experiment I rows of grain treated with copper dusts showed a slight superiority over the untreated, and a marked superiority over those treated with the strong formalin solution. In Experiment V the difference between the untreated rows and those to which copper dusts had been applied was particularly striking, every replication of certain lots showing this superiority when compared with the control. It is interesting to notice in this experiment that six lots which gave at harvest 10.8 to 41.4 per cent. bunted heads, obtained for brairding and growth in January a range of marks varying from 3.8 to 4.3 (average 3.9), whereas eight lots with only .9 to 4.3 per cent. bunted heads were marked on the same date 4.6 to 5.0 (average 4.8).

In Experiment IV again, with both pure lines under test, the copper carbonate treated rows were superior in vegetative growth to the untreated when examined at the end of April.

(3) *Average number of tillers per row at harvest.*

One of the most outstanding results in this series of experiments is the difference at harvest between the number of tillers per row in the untreated and treated lots in Experiments I, IV and V. Ignoring the strong formalin rows in Experiment I there appears on the whole to be a distinct negative correlation between the percentage bunted heads produced in the crop at harvest, and the average number of tillers (bunted and healthy together) per row. Thus in Experiments I and V we get the following figures:—

	Percent. bunted heads.		Number of tillers per row (bunted and healthy).	
	Average.	Range.	Average.	Range.
Experiment I.				
Untreated ...	10.44	7.3 —13.6	221	154—254
Treated (lots 2, 3 and 4)	2.99	.84— 4.19	280	277—283
Treated (lots 5, 6, 7 and 10) ...	0.30	0.0 — 0.69	320	302—329
Experiment V.				
Untreated ...	41.4	27.0 —54.0	354	271—464
Treated (lots 2—6) ...	17.7	10.8 —29.1	386	366—407
Treated (lots 7—14) ...	2.3	.9 — 4.3	559	460—643

In Experiment IV, where treatment with copper carbonate has reduced the disease from 39.3 and 42.3 to 1.2 and .9 per cent. in the two pure lines, the treated lots show respectively 33 and 24 per cent. increase in number of tillers when compared with the untreated rows.

In Experiment III, on the other hand, the replications of all treatments were much more uneven; and we find in some cases an increase, in others a decrease, in the number of tillers comparing treated and untreated lots.

A similar increase in the total number of heads at maturity has recently been recorded by Neill (15) in the case of grain treated with "uspulun," "germisan," "semesan" and copper carbonate.

(4) *Weight of straw and grain.*

The control of bunt by every method (excepting perhaps the strong formalin in Experiment I) has been followed by a substantial increase in total yield, grain plus straw, and in the yield of healthy grain. Even the removal of spores by washing in tap water, thereby reducing bunt from 35 to 18 per cent., has resulted in an increase in grain yield of 30 per cent. Common salt again has reduced bunt from 10 to 4 per cent. and given an increase of 25 per cent. in grain yield. In Experiment V, taking the average of eight applications

TABLE IX.

A comparison between untreated lots and those in which bunt was controlled by copper dusts in regard to number of tillers and yield of grain.

Ref. to Expt.	Year.	Variety.	Percent. bunted tillers: Untreated.	Percent. bunted tillers: Treated. Copper dusts.	Av. number of tillers per row at harvest: Untreated.	Av. number of tillers per row at harvest: Treated.	Av. yield of grain per row: Untreated. Grammes.	Av. yield of grain per row: Treated. Grammes.	Grain yield of untreated in terms of treated at 100.	Percent. difference in grain yld. in favour of treated.	Grain yld. of treated in terms of untreated at 100.
I.	1923	April Bearded ...	10.4	.51	221	312	158	220	72	28	139
III.	1924	Hen Gymro Ca. 583	35.1	2.8	274	263	123	186	66	34	150
IV.	1925	Hen Gymro 209 Ca.	39.3	3.16	276	359	163	400	41	59	245
		Hen Gymro 219 Ca.	42.3	2.49	289	358	196	413	47	53	211
V.	1925	Standard Red ...	41.4	2.3	354	559	210	487	43	57	232

of copper dusts, each of which has reduced bunt to 4.3 per cent. or under, the increase in grain yield of the treated over the untreated is 132 per cent. An increase of over 100 per cent. was again obtained in Experiment IV, in which treated and untreated lots of two pure lines of Hen Gymro were compared. It has already been explained that in the case of the varieties under test practically every grain on an affected head was bunted. It follows, therefore, that the withdrawal of the bunted heads from the untreated rows gives an approximately correct estimate of the loss in grain yield due to the production of bunted grain instead of normal grain.

In Table IX untreated lots are compared with lots successfully treated with copper dusts in regard to the total number of tillers per row at harvest and the final yield of healthy grain. It is evident that in four cases out of five the percentage increase in grain yield following treatment is substantially in excess of the gain that can be attributed to the substitution of normal for bunted grain. It would appear highly probable that the bunt fungus exercises an effect over and above that which is finally recognisable in the form of bunted grain—an effect which appears to have shown itself in the earlier reduced vigour of bunted plants, in the reduced number of tillers at harvest, and in the remarkably low yield of healthy grain from badly infected units. In view of the fact that the present trials have not included as controls *bunt free* lots, treated and non-treated, it is not at present possible to say definitely that the increased vigour shown in augmented tillers and strongly indicated from notes during growth has not been due wholly, or in part, to some stimulating influence of the chemicals employed. The evidence is, however, sufficient to indicate clearly that we are no more justified in assuming that increased vegetative vigour following treatment is the result of a " stimulating effect " produced by the chemicals than we are to assume that it is due to the elimination of the fungus. It must, therefore, be recognised that the problem of treatment for bunt in relation to the growth and yield of the wheat plant must be investigated from two points of view, namely,—(1) the influence, if any, of the fungi *Tilletia tritici* and *Tilletia levis* on the germination of the seed and on the establishment, growth and yield of the plant, apart altogether from the obvious result produced by the formation of bunted grains; (2) the effect of copper dusts and other treatments both on bunt-contaminated and on bunt-free samples of wheat.

Experiments on both lines of investigation were started by the present writers in the spring of 1924. That copper salts have no

influence on the wheat plant is not yet established, but from certain results so far obtained the apparent "stimulating effect" of copper dusts appear to be due chiefly to the inhibiting influence of the treatment on the development of bunt.

The following summary contains the chief results of the five experiments described in the present paper.

Summary.

1. Bunt in wheat was controlled, but not completely eliminated, by the application of copper dusts.
2. The best control was given by dehydrated copper sulphate and high grade samples of copper carbonate containing about 50 per cent. copper applied at the rate of two ounces per bushel of grain. Dusts containing lower percentages of copper were more effective applied at the rate of four ounces per bushel.
3. "Uspulun" and "germisan" (two experiments) gave approximately the same control of bunt as the better grades of copper carbonate.
4. Two formalin solutions (1:320 and 1:480) tested together (one experiment) were almost equally effective as regards bunt control. On the whole, formalin was not quite so effective as the better grades of copper carbonate, and in one experiment the stronger solution caused injury to the grain.
5. Control of bunt was accompanied by better growth in the field, an increase in the number of tillers per row at harvest, and a remarkably high increase in grain yield, amounting in three cases to over 100 per cent. (Table IX).
6. The results seem to indicate that the fungus *Tilletia tritici* has an adverse effect on the plant over and above that obviously shown by the replacement of healthy grain by bunted grain. Since no bunt-free samples of grain were included in these trials it is, however, impossible to discriminate absolutely between the effect of the fungus and a possible "stimulating effect" on the plant of the chemicals employed. Further experiments are in progress including bunt-free and bunt-contaminated grain.

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STUDIES IN THE INHERITANCE OF RESISTANCE AND SUSCEPTIBILITY TO CROWN RUST (*P. CORONATA* CORDA) IN A CROSS BETWEEN SELECTIONS OF RED RUSTPROOF (*A. STERILIS* L.) AND SCOTCH POTATO (*A. SATIVA* L.).

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Introduction.

The breeding of varieties resistant to specific diseases is receiving considerable attention at the present time. Since Biffen (5), (6), (7), published his results on the inheritance of resistance and susceptibility to Yellow Rust (*P glumarum*) in hybrid wheats and showed that disease resistance was inherited in a definite Mendelian manner, numerous other investigators dealing with crosses of various species of plants have confirmed the possibility of transferring this character, combined with others of economic importance, in fixed types of hybrid progeny. Although all agree that inheritance of resistance and susceptibility to disease is Mendelian in its behaviour,

the manner of inheritance is found to vary according to the nature of the material used. Resistance in some crosses is dominant, in others recessive, and is determined in some cases by single and in others by multiple factors.

Owing to the diversity in the behaviour of resistance as found by former workers when crosses of a different nature are involved, it appears that when an improvement of a particular susceptible variety is contemplated, a preliminary investigation into the mode of inheritance of the resistance to the disease under consideration is necessary before any selection work can be intelligently carried out.

Observations made on numerous varieties of Oats, both at the Welsh Plant Breeding Station and in the surrounding counties, have shown the prevalence of Crown Rust in this area, and the extreme susceptibility of all the commonly grown varieties. Amongst these the susceptibility of Scotch Potato was most marked. Although this variety is undoubtedly one of the most susceptible to this disease it is somewhat surprising that it retains its popularity amongst the farmers of this part of the country.

The aim of the present investigation is to obtain information on the mode of inheritance of resistance and susceptibility to Crown Rust as a preliminary to further work in the improvement of local varieties of Oats, which is now being carried out at the Station.

Historical.

It is beyond the scope of the present article to deal with the extensive literature bearing upon the general problem of disease resistance in plants. References will therefore be confined more particularly to papers concerning the inheritance of rust resistance in various types of wheat, and to the occurrence of biologic forms of rust, and especially to papers dealing more specifically with the problem in so far as it has been dealt with in Oats.

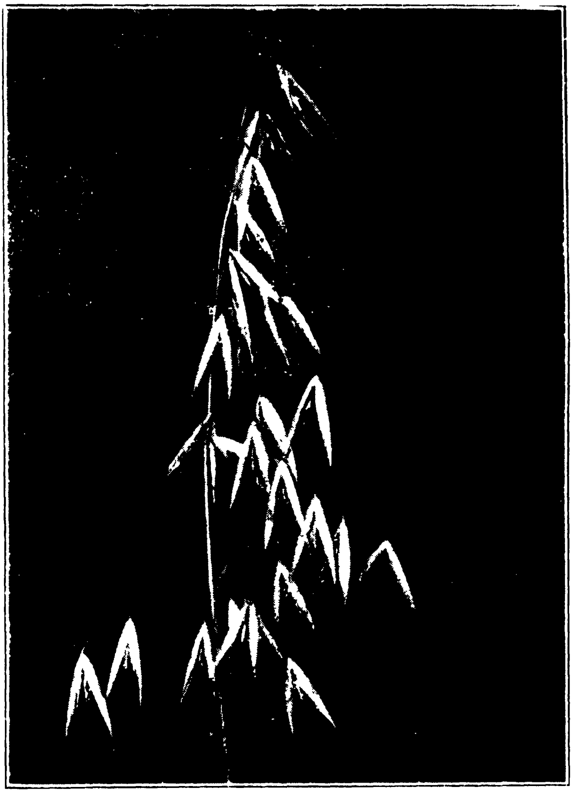
Biffen (5), (6), (7), in his studies with Yellow Rust (*P. glumarum*) found resistance to be inherited as a simple Mendelian recessive in crosses between resistant Rivet and susceptible common Wheats. This conclusion was arrived at from results obtained with segregates of F_2 and F_3 generations grown under natural field conditions.

Nilsson-Ehle, quoted by Newman (17), working with other varieties of Wheat, obtained more complicated segregation, and suggested the presence of multiple factors in explanation of his results. No instances were obtained of uni-factorial segregation. Hayes, Parker and Kurtzweil (13), in their investigation into the

inheritance of resistance to Stem Rust (*P. graminis tritici*), recorded susceptibility under the conditions of a specially prepared disease plot, as being a dominant character in crosses between resistant durum and susceptible common wheats, and a recessive character in crosses between emmer and susceptible common wheat. Indications were also found of a linkage between durum or emmer characters and rust resistance; resistant common wheat types were, however, obtained in small numbers. Melchers and Parker (16), working with crosses between varieties of common wheat under greenhouse conditions, found resistance to Stem Rust to be inherited on a single factor basis, resistance being dominant. These conclusions were drawn from inoculations made at time of heading and refer to F_1, F_2 and F_3 generations. Aamodt (1), (2), working with similar varieties obtained similar results. In another paper (3) his experiments indicate that apparently a single factor difference determines the reaction to several biologic forms.

As far as can be ascertained Parker (19) appears to have been the first investigator to publish details of inheritance of resistance to Crown Rust in Oats. His experiments were concerned with pure lines of Burt (*A. sterilis* L.) and Sixty Day (*A. sativa* L.) and crosses between these varieties. Burt, the resistant parent, was found to vary in its reaction to Crown Rust, some individuals being definitely resistant, others moderately so, whilst a number were just as susceptible as the susceptible Sixty Day parent. The five F_1 plants derived from crossing these two varieties also showed variability in their reaction to infection in the F_2 generation; two families gave 20 and 29 per cent. resistant plants, and three as low proportions as 1.9, 6.2 and 4.4 per cent. resistant types respectively. In all five families there was an absence of clearly defined segregation into resistant and susceptible groups. Susceptibility was at least partially dominant, but the existence of a series of intermediate forms grading from resistant to susceptible complicated the problem of accurately grouping the types obtained. No observations were made on the reaction of the F_1 plants. From the behaviour of the individuals of the F_2 generations and the variability in resistance of the Burt parent, it was concluded that the results cannot be satisfactorily explained on a single factor basis, and that the observed gradations between resistant and intermediate plants were due to the presence of multiple factors, the nature of which still remains to be determined. Emphasis, however, was laid primarily upon the fact that the character of rust resistance is inherited in Oat hybrids in Mendelian manner, and that it appears

PLATE I.



MATURED PANICLE OF THE RESISTANT PARENT. (SELECTION OUT OF THE VARIETY RED RUSTPROOF A. STERILIS, L.).

in a certain number of the F_2 generation plants. These observations relate to the study of seedling inoculations under greenhouse conditions. A number of tests were also carried out with plants at the time of heading and their reactions fully agreed with the behaviour shown in the seedling stage. Garber (11), in his studies on the inheritance of resistance and susceptibility to Stem Rust, crossed White Russian (*A. sativa orientalis*) with Minota and Victory—two susceptible varieties of the *A. sativa* group. In the F_2 generation he obtained segregation into two clearly defined groups —resistant and susceptible. The cross Minota × White Russian gave 104 resistant and thirty-six susceptible, and that of White Russian × Victory thirty-one resistant and nine susceptible. Resistance was inherited as a simple dominant character. These results were obtained with seedling and with matured plants grown under field conditions, aided by the artificial application of rust spores. Similar crosses were investigated by Griffee (12), whose results are in agreement with those obtained by Garber.

Considerably more work has been done in the direction of investigating the varietal resistance of Oats to Crown Rust. Barnett (8) found that the amount of leaf rust infection in Red Rustproof (Red Texas) was much less than in other varieties. Reed (20), and also Brentzel, some of whose results were recorded in the same paper, found his variety to be 100 per cent. susceptible to *P. Coronata* Corda. Parker (18), using seedlings and plants in the heading stage, found several varieties of the Red Oat Group (*A. sterilis* L.) to be resistant to Crown Rust. Amongst these, one strain, and two selections of Red Rustproof, were susceptible, and one selection showed a high degree of resistance. Durrell and Parker (9) found indications in the greenhouse and in the field that varieties of the Red Oat group showed more resistance to Crown Rust than those of the common Oat group (*A. sativa* L.), and that the variety Red Rustproof showed more resistance to Crown than to Stem Rust.

The possibility of sterility influencing the results obtained has been shown by Wakabayashi (22), who recorded sterility to the extent of 25 per cent. in the variety Red Rustproof; and in the F_1 of a cross Red Rustproof × Black Tartarian it was as high as 62 per cent.—the cross being higher in sterility than the parents. Owing to the sterile strains eliminating themselves the percentage decreases in the later generations.

Description of Varieties and Materials Used.

The results briefly reviewed in the previous section on the varietal resistance of Oats to Crown Rust, together with observations made

at the Station, indicate that varieties of *Avena sterilis* L. would afford the most promising material from which to select a rust resistant parent. Amongst varieties of this species grown at the Station, Red Rustproof was found to contain a number of resistant plants, and from amongst these a suitable selection to be used as parent was obtained. The original bulk sample of this variety was received from the U.S. Department of Agriculture in 1920, the sample having been grown at Arlingham Farm in 1919.

The susceptible parent was taken from a bulk sample of the variety Scotch Potato, originally obtained from the Midlothian district of Scotland in 1920. This variety belongs to the species *Avena sativa* L.

Both these varieties have been described in detail by Etheridge (10), Marquand (15), Archer (4) and others. Etheridge also obtained such different varieties as Danish Island and Burt under the varietal name of Red Rustproof. The selection from Red Rustproof (see Plates I and IIIa) used in the present work agrees very closely with the description of that variety as given by Etheridge and Archer. The Scotch Potato selection (see Plates II and IIIb) may be regarded as typical of that variety as described by Marquand (15).

Hybridization of the parents was carried out in the Span Greenhouse in the garden of the Station in the summer of 1923. Necessary precautions were taken to safeguard the parents crossed from contamination by foreign pollen. Five viable hybrid grains resulted from the cross (Red Rustproof × Scotch Potato). It is unfortunate for the purpose of comparison in this investigation that the reciprocal pollination failed to give any seed.

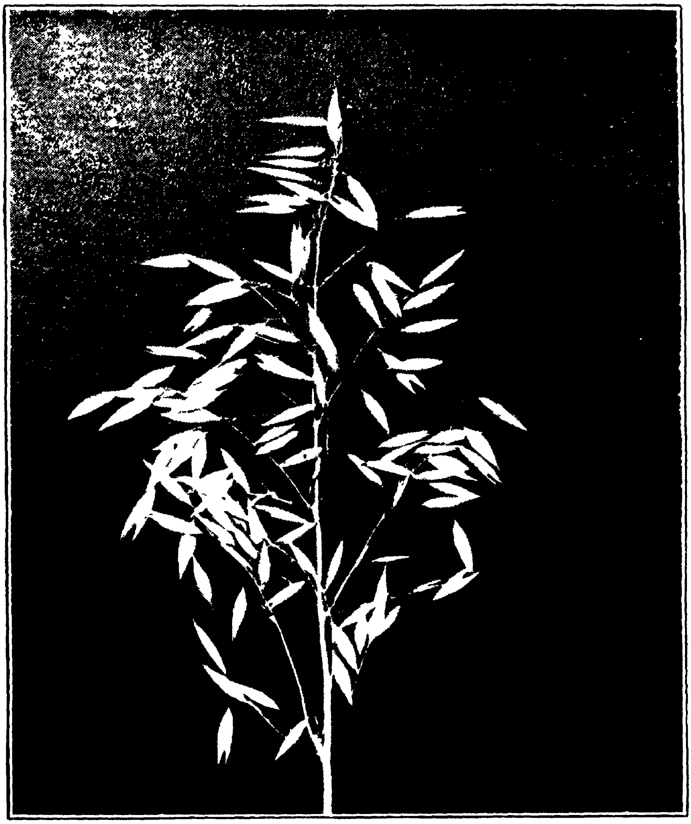
The parent and hybrid grains were germinated in pots in the greenhouse in the spring of 1924, and later, when the seedlings were from 6—8 inches high, they were planted out in the cereal cage as single spaced plants.

Apart from inoculations and reactions of the five F_1 hybrid plants it is with the lineal descendants of both parents, and the F_2 seedlings of one F_1 hybrid plant, that the studies herein reported are particularly concerned.

Technique adopted and Methods of Recording Results.

As a result of the work of Stakman, Levine and Leach (21) with Wheat, and of Hoerner (14) with Oats, the possibility of super biologic forms occurring within Crown Rust on Oats was fully realised. The necessity of working with only one form was

PLATE II.



MATURED PANICLE OF THE SUSCEPTIBLE PARENT. (SELECTION OUT OF THE VARIETY SCOTCH POTATO A. SATIVA L).

consequently considered imperative if satisfactory results were to be obtained. Precautions were therefore taken to eliminate as far as was practicable the possibility of working with more than one biologic form. This was done by selecting from a plot of Potato Oats a leaf which carried only a few pustules. The spores gathered from these pustules were then used to inoculate seedlings of the same variety growing in the greenhouse. By transferring at regular intervals, sufficient spore material was obtained to test the F_1 generation *in situ* during the spring of 1924, and later to continue the investigation with the F_2 seedlings in the greenhouse during the early months of 1925.

The F_2 generation seedlings were grown in 5-inch pots at the rate of 12—14 per pot. This number was found to be the maximum that could be conveniently grown without the plants becoming pot-bound towards the end of the period of observation. These were planted twice weekly in series of six pots each, and with each series a pot of Potato Oats was included to act as control. They were then placed in muslin compartments in the greenhouse until the first leaf was fully expanded. The young seedlings were thus fully protected from outside infection. At this stage the plants were inoculated by transferring spore material from cultures, by means of a scalpel, on to the leaf to be inoculated. After each pot was treated in this manner, the seedlings were sprayed with rain water by means of an atomizer and afterwards placed in a moist chamber for forty-eight hours—ample water being given to the plant during this period—after which they were taken out and placed on the bench sufficiently removed from stock cultures to prevent contamination.

Daily observations were made and notes taken on points relative to reaction, which were considered necessary for the subsequent classification of types, and for the elucidation of the mode of inheritance of resistance to the disease in question.

Statement of Results Obtained.

In order to test the purity of the parents, lineal descendants of each were inoculated at the same time as the seedlings of the F_2 generations. Of the seventy-five plants of Red Rustproof tested all proved to be uniformly resistant in reaction. All the seedlings showed the type of flecking usually associated with resistance in Oat varieties, and in no case was there any evidence of the development of even weak pustules. The Scotch Potato gave uniformly susceptible reactions. The sixty seedlings tested developed normal pustules characteristic of the rust fungus, and no indications were observed of any variation in this respect.

The F_1 hybrid plants inoculated *in situ* reacted uniformly; very heavy flecking first of all appeared, and this was accompanied later by the development of weak uredosori. Characteristically the reaction was similar to that of resistant plants.

In the F_2 generation 1,041 plants were tested. Out of this total six were discarded as exhibiting no effective results of inoculation, one way or the other. A definite reaction was observed in all the remaining plants. This in the early stages took the form of very faint flecking, and at the 12th—15th day distinct and characteristic variations appeared. In some of the plants this was in the nature of water-soaked areas, which by the 14th to the 16th day developed normal uredosori typical of susceptible plants and similar to those of the control pots. In others the flecking appeared in the form of discoloured areas which became more intense with the lapse of time, and in a few cases weak uredosori developed, but the majority remained as discoloured or flecked areas. A few instances, however, were observed of seedlings which showed pronounced discolorations or flecking in the early stages, which later developed normal pustules. Six of this type were recorded, and these were subsequently classified with the susceptible group.

The length of the infection period is regarded by some investigators as additional evidence of resistance. It has been found, however, that low temperature has a marked influence in prolonging this period. As it was not possible to maintain the greenhouse at a fairly constant temperature during the course of the experimental work, this evidence of resistance was regarded as of subsidiary significance in arriving at the classification of results. Two main types of reaction thus appear:—

(1) Those which are heavily flecked with or without the development of weak uredosori (see Plate IV R).

(2) Those which developed normal uredosori (see Plate IV S).

On this basis of classification 258 seedlings were recorded as susceptible, and 777 were determined as resistant. Of the latter, 660 showed characteristic fleckings without any pustules, and 117 developed weak uredosori.

Determinations of the percentage sterility in one of the F_1 hybrid plants showed that out of a total of 567 flowers twenty-six were sterile, or a percentage sterility of 4.5.

Discussion of Results and their Interpretation.

The interpretation of results depends largely upon the classification of the different types of reactions obtained. These, in the present investigation, appear very definitely to fall into two distinct

PLATE III.

(*a*) SPIKELETS OF THE RED RUSTPROOF SELECTION.
(*b*) SPIKELETS OF THE SCOTCH POTATO SELECTI

groups, namely, resistant and susceptible. The distinction between the reactions of the two groups was sharp and definite, but within the resistant group itself there were slight gradations ranging from complete absence of uredosori, similar to that exhibited by the resistant parent, to the presence of small, weakly-developed pustules similar in type to those found on the F_1 hybrid plants. The number of the latter type is small, in comparison with the extremely resistant type, and suggests the presence of some modifying influence or the incomplete dominance of the factor for resistance. The other group was uniformly susceptible, all individuals producing normal infection similar to the susceptible control (see Plate IV C).

The reaction of the F_1 plants undoubtedly shows a very slight weakening in resistance when the factor or factors for resistance are in the heterozygous condition. Resistance thus appears to be almost, but not quite completely, dominant. This, however, does not appear to be true of all heterozygous genotypes as shown by the occurrence in the F_2 generation of only 117 phenotypes of this description out of a possible 518, the number calculated and expected on a single factor basis of inheritance.

The grouping, obtained under the circumstances of this investigation, undoubtedly suggests the transmission of the characters resistance and susceptibility, as defined above, to be unifactorial: the numbers being 777 resistant and 258 susceptible. These are in fairly close agreement with the theoretical expectation on a mono-hybrid basis, namely, 776.25 resistant and 258.75 susceptible. Furthermore, the amount of sterility, as exhibited by counts on one F_1 hybrid plant, can not be considered sufficiently high to in any way seriously influence what appears to be a mono-hybrid ratio.

The results recorded above differ from those obtained by Parker in resistance being dominant instead of recessive, and the mode of inheritance determined by simple and not multiple factors. They are, however, in agreement with those of Garber and Griffee, who found resistance to be inherited as a simple dominant character in studies with the rust fungus *P. graminis tritici.* It is significant, however, to note that the results so far recorded of the mode of inheritance of rust resistance in crosses between different species and varieties of oats show much the same diversity as similar studies with species and varieties of wheat. Thus Biffen, and also Hayes, Parker and Kurtzweil, have shown rust resistance to behave as a simple recessive; Hayes, Parker and Kurtzweil, Melchers and Parker, and Aamodt, as a simple dominant; and Nelsson-Ehle, as a complex character involving multiple factors.

The writers are indebted to Professor Stapledon, Director of the Welsh Plant Breeding Station, for facilities in connection with the experimental work, and for his interest and criticism during the progress of the investigations.

Summary.

1. Investigations are recorded on the inheritance of resistance and susceptibility to Crown Rust (*P. Coronata* Corda) in a cross between selections of Red Rustproof (*A. sterilis* L.) and Scotch Potato (*A. sativa* L.).

2. The strain *P. Coronata* used in the present research was originally collected from the variety Scotch Potato.

3. With the exception of the F_1 hybrid plants, which were inoculated *in situ*, seedlings of both parents, and of the F_2 generation of one F_1 hybrid, were inoculated and studied under greenhouse conditions.

4. Of the seventy-five seedlings of the Red Rustproof parent inoculated, all were uniformly resistant, and of sixty seedlings of the Scotch Potato parent all were equally susceptible. The five F_1 hybrids showed a high degree of resistance. Out of 1,041 plants of the F_2 generation 777 were classified as resistant, and 258 as susceptible, and six seedlings exhibited no reaction to inoculation.

5. Resistance in the F_1 generation behaves as a partially dominant character, and with its allelomorph susceptibility segregates in the subsequent generation in the ratio of three resistant to one susceptible.

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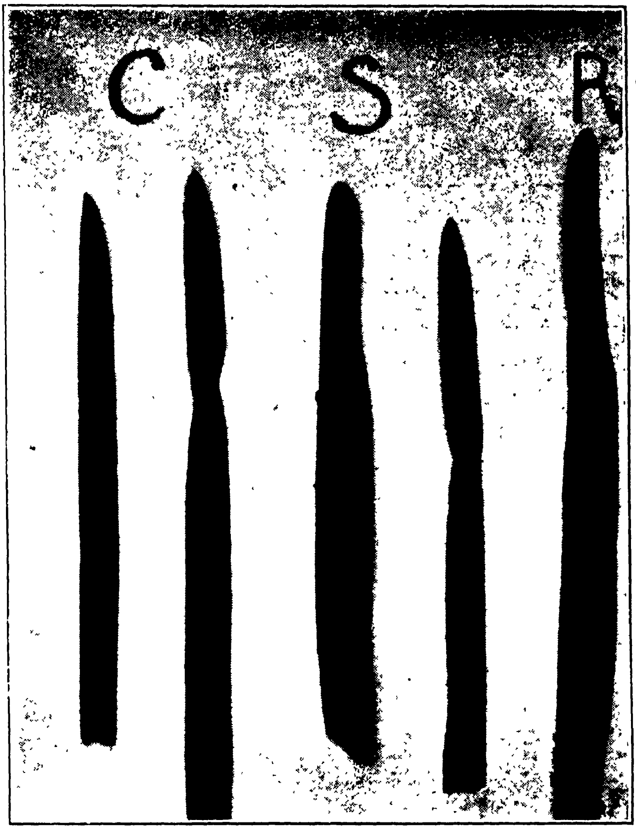
PLATE IV.



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NOTES ON THE INSECT PESTS OF RED CLOVER IN MID AND WEST WALES.

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In Wales, pre-eminently a pastoral country, the clover crop is of high importance, not only from the pasture and forage aspect, but also, in certain districts of Montgomeryshire and the Vale of Clwyd, from the seed production aspect. For this reason, and also, because the insect pests of clover have received little attention, in comparison

with those of other cultivated crops, the writer has devoted special attention to those pests during a general survey of the insect pests of Mid and West Wales. A short account is here given of some of the more commonly occurring pests, which is followed by observations on an experiment now in progress by which an attempt is being made to estimate the damage to a clover crop by leaf-eating weevils.

Amongst the very numerous pests of clover which have been observed in the area, the ones here referred to are of general occurrence and in some cases highly detrimental to the crop.

Weevils.

CLOVER APION SPP. These small weevils, several species of which attack red clover in Wales, are responsible for two types of injury, the adults feed on the leaves, and the larvae feed either in the flowerheads on the developing seeds, or in the stems, according to the species concerned. They are of universal occurrence. The most common species are *A. assimile* and *A. trifolii*, the larvae in both cases feeding in the flowerheads. *A. virens*, whose larva feeds in the stems, is fairly common. *A. apricans*, with a flowerhead feeding larva, has so far proved to be uncommon, whilst *A. tenue*, *A. nigritarse* and *A. dichroum* are uncommon and occur very sparingly. It is possible that in cases of heavy infestation, earlier cutting for hay might result in considerable larval mortality owing to the flowerheads drying up before the larvae are full fed, and might so cause a reduction in the numbers of these pests. An experiment is now being carried out by the writer, in collaboration with the School of Agriculture, Cambridge, to test the value of this procedure.

CLOVER SITONES SPP. These weevils, like the foregoing, are of universal occurrence, and also resemble them in being responsible for two types of injury. The adults feed on the foliage, and the larvae on the roots, root hairs, and root nodules, the exact nature of larval injury depending upon the species present. *S. sulcifrons* is the only species which has been found occurring in numbers, often causing considerable damage. Although a certain amount of adult feeding takes place throughout the winter, it is not until the warmer spring days that the weevils emerge in numbers and attack the young spring growth. As many as thirty-seven weevils have been taken from four red clover plants in early spring, whilst considerable injury has been noted to clover seedlings. The larvae feed on the root nodules and the small fibrous roots which bear them. Other species which occur on red clover are *S. hispidulus*, *S. lineatus*, *S. crinitus* and *S. flavescens*.

Clover Phytonomus spp. A point of interest in connection with these weevils is that during recent years they have multiplied to such an extent in certain states of the U.S.A., and caused such enormous damage, to lucerne in particular, that State legislation became necessary to prevent their introduction from infected states to clean states. In the area now under survey they appear to be generally distributed, and although not numerous in some districts, in others they are numerically strong and distinctly injurious, the heaviest infestation noted being when forty-seven larvae were taken from ninety-six flowerheads. Fortunately, natural control appeared to be fairly efficient in this case, as 25 per cent. of the larvae were found to be parasitised by a small Hymenopteron, and subsequently failed to develop. The most commonly occurring species is *P. nigrirostris.* Both adults and larvae feed on foliage and flowerheads, the former being damaged mainly by the adults, whilst the larvae concentrate chiefly upon the flowerheads. *P. trilineatus* is another commonly occurring species, and in some districts is almost as strong numerically as *P. nigrirostris.* Other species which have been found in small numbers are *P. punctatus, P. rumicis* and *P. polygoni,* the two last named probably being accidental visitors.

Moths.

The larvae, or caterpillars, of several moths are known to be injurious to red clover. Larvae of the following species have been taken, but have never been found in numbers sufficiently large to be of economic importance. *Plusia gamma,* the Silver Y, *Euclidia glyphica,* the Burnet Companion, *Euclidia mi,* the Mother Shipton, *Zygaena trifolii,* the Five Spot Burnet, *Zygaena lonicera,* the Narrow Bordered Five Spot Burnet, and *Zygaena filipendulae,* the Six Spot Burnet.

Midges.

Two species of Cecidomyidae, or Gall Midges, are definitely known to cause damage in the area, *Amblyspatha ormerodi* and *Dasyneura leguminicola,* but it is probable that other species also occur. The former species, or Clover Midge, has only once been found causing serious damage, when practically the entire clover crop was destroyed. The small pinkish maggots are found in the base of the plant almost at ground level, they feed in the apical tissue and small side shoots, causing the tissue to rot away. *D. leguminicola,* the Clover Seed Midge, appears to be generally distributed, the pinkish larva feeds inside the corollas on the young ovules and prevents seed formation.

Green Flies and Plant Bugs.

Five species of Aphides commonly occur on Red Clover in the area. Four of them, *Macrosiphum malvae, Macrosiphum pisi, Myzus circumflexus* and *Myzus persicae,* are found on the leaves or stems, the last named being the only one which has been found in large colonies. The fifth species, *Anuraphis warei,* attacks the flowerheads; it appears to be commonly distributed with very heavy infestations in some cases. Four species of plant bugs are common on Red Clover, *Lygus pratensis, Calocoris norvegicus, Miris calcaratus* and *Miris laevigatus.* They have been found in all districts visited, sometimes occurring in enormous numbers. The injury caused by greenflies and plant bugs is similar and two-fold; the vitality of the plant is lowered through the piercing of its tissues and sucking of its juices, whilst the breaking of the epidermis during feeding operations causes a wound which affords a favourable point of entry for disease causing fungus spores.

Illustrations of some of the pests referred to above will be found at the end of the present article.

Reference was made at the commencement of the present paper to the fact that comparatively little work has been done on the insect pests of clover. One of the many points upon which information is required, is the effect of insect attack on clover seedlings, and the following observations relate to an experiment now in progress by which it is hoped to obtain that information. The account here given relates to the first year's growth only, and is to be regarded as a progress report.

An examination of any seeds mixture soon after germination under field conditions, will invariably show that a certain percentage of the clover seedlings have been attacked by leaf-eating pests, of which *Sitones sulcifrons* is the chief offender, although slugs are in many cases almost as injurious. The attack commences at the cotyledonary leaf stage, and continues throughout the life of the plant, with a consequent reduction in the amount of leaf surface. Destruction of foliage is always important, since it means a loss of assimilating tissue, but destruction of the cotyledonary leaves and the first true leaf is doubly important as assimilating power is lowered at the most critical period in the history of the plant, when it is establishing itself. This must result in at least a temporary setback, and the question arises as to whether the setback is confined to the seedling stage, or whether its effects persist, and

result in a reduction of the subsequent yield. The experiment here described is an attempt to answer the question. Montgomery Red Clover seed was sown in boxes under glass on November 24th, 1924, and on January 20th, 1925, artification semi-defoliation was carried out. At this date the great majority of the seedlings possessed two cotyledonary leaves and one true leaf; in a few the second true leaf was present but was not fully expanded. The semi-defoliation was carried out by carefully cutting away the apical half of the existing leaves with a pair of fine scissors. Half of the seedlings were so treated, the remaining half being left undefoliated as a control. The semi-defoliation did not result in the death of any of the seedlings. On March 17th, 1925, the young seedlings were transferred to pots, hardened off in a cold frame, and finally removed to a flat roof where they remained until the foliage was cut. The plants were at all times kept as far as possible sheltered from insect attack, and in the few cases in which damage to the leaves occurred, the plants were discarded. On July 1st, 1925, the plants were in about three-quarter flower, and each plant was carefully cut with scissors to ground level and the green weight taken at once. The possible presence of any external moisture was ruled out by the fact that the plants were cut during the drought period, and since weighing took place immediately after cutting, no loss of weight took place through evaporation. The total number of flowerheads on each plant was also noted. The necessity for economy of space prevents the results being given in detail, but they may be conveniently expressed in the following tabular form:—

	Plants from the semi-defoliated seedlings.	Control plants.
Total number of plants ...	50	47
Total green weight	171.28 gm.	226.27 gm.
Average green weight per plant ...	3.43 gm.	4.81 gm.
Probable error	±0.18 gm.	±0.30 gm.
Heaviest plant (green weight) ..	10.37 gm.	17.53 gm.
Lightest plant (green weight) ..	0.61 gm.	0.88 gm.
Total number of flowerheads ...	87.	118.
Average number per plant ...	1.74	2.51
Probable error	±0.17	±0.20
Highest number per plant ...	7.	12.
Number of plants with none ...	17.	4.
Co-efficient of correlation between weight of plant and number of flowerheads	.9605	.8625

Since both semi-defoliated and control plants were kept under the same conditions throughout the experiment, and were treated in

exactly the same way, it is clear that any difference between the two groups must be due to the effect of the semi-defoliation. Also, since the difference between the average weights per plant, and between the average numbers of flowerheads per plant, is more than three times their respective probable errors, the results are significant. It is a justifiable conclusion, therefore, that as a result of the semi-defoliation of the clover seedlings there was, at the end of seven months growth, an average loss in green weight of 1.38 gm. per plant, that is, an average loss of 28.7 per cent. of the total green weight, and an average loss of 0.77 flowerheads per plant, that is, an average loss of 30.7 per cent. of the total number of flowerheads.

An attempt was next made to apply these results to field conditions, and counts were therefore made of clean and attacked seedlings in a clover stand at the Welsh Plant Breeding Station, and the following results obtained:—

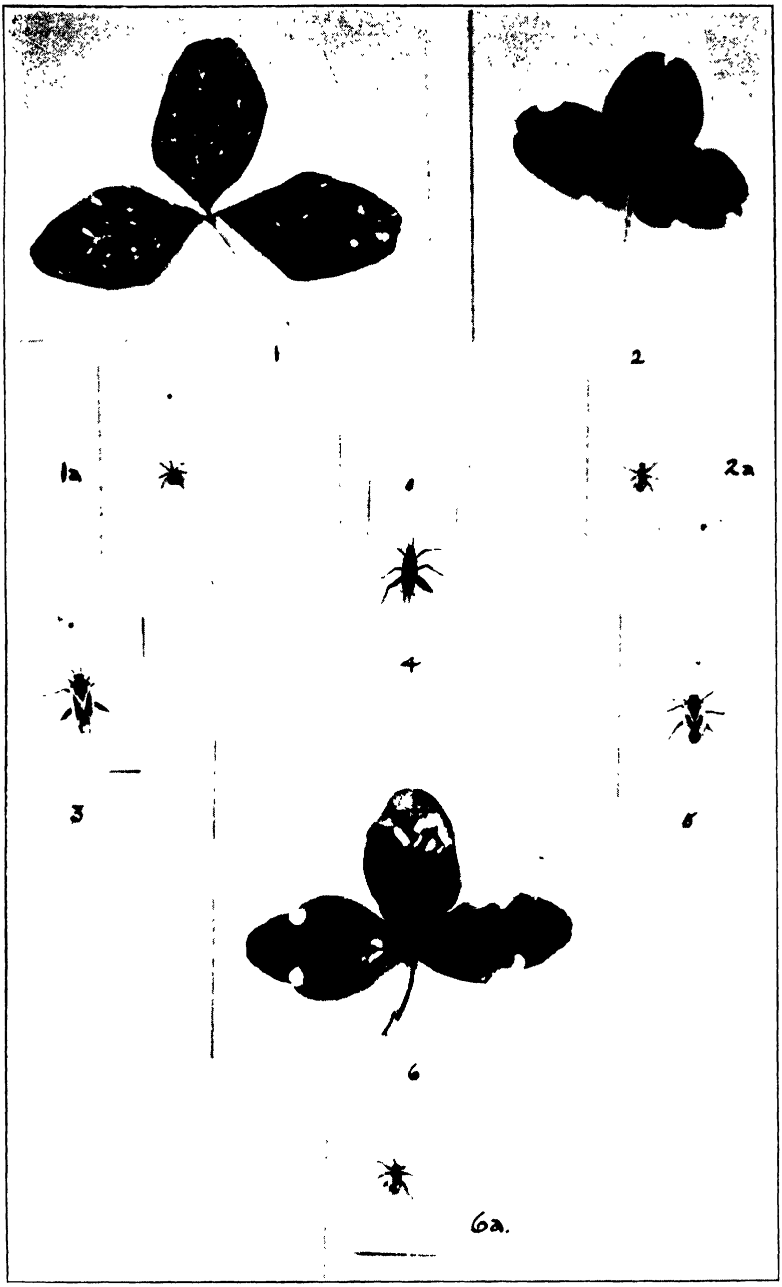
Total number of seedlings examined ...	2,620.
Number of clean seedlings	1,704 = 65 per cent.
Number of attacked seedlings	916 = 35 per cent.

Further considering the attacked seedlings, the following figures illustrate the degree of attack:—

Seedlings with one cotyledon attacked	71 per cent.
Seedlings with both cotyledons attacked	29 per cent.

All the seedlings were in the cotyledonary leaf stage when the observations were made. It was impossible to measure accurately the exact loss of leaf surface by each attacked plant, but it was estimated that in this particular attack the average loss per attacked leaf was at least 60 per cent., some being practically destroyed, in some cases entirely so, whilst in others the damage was less, thus giving an average defoliation of 38.7 per cent. If this estimation be accepted as correct, then 35 per cent. of the clover stand examined suffered at least a 38.7 per cent. defoliation. If these figures are correlated with the results of the semi-defoliation experiment described above, it is found that, as a result of attack by *S. sulcifrons* on the clover stand under consideration, a loss of 7.8 per cent. of the total green weight at the end of seven months' growth may be expected.

Thus the only information of practical value which has been obtained so far from the experiment and the observations described above, is that insect injury to clover seedlings in the spring may result in a definite loss of autumn keep, that is, of stubble grazing. Unpublished results obtained by Professor Stapledon, of the



1. Clover Leaf showing damage caused by *Apion assimile.*
1a. *Apion assimile.*
2. Clover Leaf damaged by *Sitones sulcifrons.*
2a. *Sitones sulcifrons.*
3. *Calocoris norvegicus.*
4. *Miris calcaratus.*
5. *Lygus pratensis.*
6. Clover Leaf damaged by *Phytonomus nigrirostris.*
6a. *Phytonomus nigrirostris.*

Welsh Plant Breeding Station, show that a very conservative figure for the Red Clover content of a seeds mixture at the end of the first (seeding) year's growth is 50 per cent., and that it often exceeds 70 per cent.; any substantial loss of the clover element in stubble grazing is therefore of high importance.

It is realised that the results so far obtained do not justify any sweeping assertions or generalisations on the exact amount of loss due to insect depredations in the seedling stage, and it is possible that even a number of experiments conducted on similar lines may give no more than a general indication of the extent of such loss, since the application of experimental results to field conditions must invariably be subject to a considerable error. Even so it is thought that these and allied experiments have a value, and that the value lies in that a comparison of a sufficiently large number of results will enable an opinion to be formed as to the advisability of making a serious attempt to control the particular pest in question, and, should control appear advisable, to decide to what point the cost of the control must be limited in order that it may be an economic proposition.

In order to obtain the information necessary for the formation of such opinions, the writer hopes to repeat the experiment and observations described above, with a number of varieties of clover during the coming season.

It is also important that we should know whether the lowering of the plants' vitality by insect attack in the seedling stage is confined to the first year's growth alone, or whether it persists into the second year and thus affects the hay yield or the seed yield as the case may be. The plants used in the experiment described above are being grown on under field conditions, and it is hoped to make observations during the coming season which will throw some light on the question.

A further point which must not be lost sight of is that damage by leaf-eating pests is not confined to the seedling stage, but persists through out the life of the plant, damage to the spring growth in the second year often being severe. Then again, with the pest with which we have been more particularly dealing, *Sitones sulcifrons,* larval damage to the roots must also be considered. These further injuries must result in a further lowering of the plant's vitality and consequent yield, and must be considered when an opinion is being formed as to the advisability of adopting control measures. It is hoped during the coming season to obtain experimental evidence of the effect of these injuries.

Summary.

A list is given of the more important and commonly occurring insect pests of Red Clover in Mid and West Wales, together with a brief account of the damage caused by each pest.

An account is given of experimental and observational work which shows that insect attack on Red Clover in the seedling stage results in a lowering of the plants' vitality and consequent reduction in the first year's yield.

The value of the results is discussed, and reference made to further experiments both in progress and in view.

The writer wishes to express his gratitude to Professor Stapledon, of the Welsh Plant Breeding Station, for providing facilities for the carrying out of the work.

LEATHERJACKETS AND THEIR CONTROL.

By H. W. Thompson, M.Sc.,

University College, Cardiff.

During the early part of 1925 Leatherjackets proved a very serious pest of Autumn and Spring Corn in Glamorgan and Monmouthshire. Leatherjackets are the larvae of the Crane Fly or Daddy-long-legs, and are locally known as "Bots."

In all, about eighty acres was brought to the notice of the writer on which crops had failed entirely or had been damaged so much as to render re-sowing necessary, along with a further acreage of about sixty on which a partial failure of a severe character had taken place. Many other cases of lesser injury were also noticed. It is certain that this, extensive though it is, does not represent more than a fraction of the injury caused in Glamorgan and Monmouthshire by this pest. It is fairly clear that many other crop failures, which could be attributed to this insect, occurred but were not reported.

In every case examined the injury followed a broken up ley and as this is very rarely broken up in South Wales before egg laying takes place in the summer, the turf when turned down contains the eggs or young Leatherjackets.

The areas in Glamorgan which suffered the most from this outbreak were Rhoose, Aberthaw, Gileston, and Llantwit Major, the outbreaks occurring on some of the most fertile soil near the seashore in the Vale of Glamorgan. Two crops also failed at Lisvane. In Monmouthshire the districts around Raglan and Abergavenny were the worst noted. Leatherjackets have also been abnormally prevalent and destructive in gardens at various places in each county.

Steps to Combat the Outbreak.

Steps to combat this pest were at first directed towards the prevention of the extension of Leatherjacket injury in cases where the attack was restricted to definite areas in a crop. The substance tested for this purpose was Naphthalene, and observations made appear to show that this substance is of definite value for this purpose. A dressing at the rate of 2 cwt. per acre was applied on a strip five yards wide, bordering a very badly infested area of an Autumn wheat crop. This was applied on February 14th, 1925, and on subsequent examinations it was noted that although the Leatherjackets remained extremely numerous on the originally badly infested portion of the field, apparently none had crossed the Napthalene treated area and the attack had been restricted to a comparatively small area, which had been cleared of almost every plant, whereas the rest of the field produced a good crop.

Tests of Kainit.

In view of the fact that an application of Kainit is frequently recommended against Leatherjackets, a quarter of an acre of a badly infested crop of Autumn wheat was dressed with 1 cwt. Kainit on February 14th, with the object of determining the value of an application of this substance for this purpose. The field has since been examined on several occasions.

At no stage have any dead Leatherjackets been found, which suggests that at the strength used at any rate, Kainit has little or no insecticidal value against this pest. Leatherjackets were still as plentiful on the treated as on the untreated portion of the crop and as far as could be determined by observation the Leatherjacket attack was not checked in any way by the application. In this test the effect of Kainit on the crop itself was not taken into consideration.

Control by Poison Bait.

Poisoned bait as used for the control of Surface Caterpillars[1]

1 See *Ann. App. Biology*, July, 1923.

was tested on a field scale and some interesting results were obtained. The poisons which have been tested up to the present are:—

1. Sodium Fluoride, and
2. Paris Green.

With regard to the test of Sodium Fluoride, the procedure adopted was as follows:—Bran, 20 lb., was moistened with a solution of $1\frac{1}{2}$ ounces of Sodium Fluoride in one gallon of water, the liquid being added gradually and the Bran thoroughly stirred. The solution was added until the Bran was thoroughly moistened, but not wetted sufficiently to make it adhere together when handled. The above quantity was sufficient for broadcasting on one acre, and the application was made in the evening so that the bait would not become too dry by nightfall. Examinations were then made on the following days. Small areas of about one square foot were taken at random from different parts of the treated plot. These were dug up and all Leatherjackets seen were collected whether they were on the surface, under the old turf, or in the soil. These were then taken to the laboratory and the living and dead were separated and counted. Leatherjackets were also taken from untreated parts of the field and similarly examined for comparison.

A test of this Sodium Fluoride Bait was carried out on a heavily infested field of autumn wheat near Rhoose, Glamorgan. The application was made to three-quarter acre on February 17th, and collections of Leatherjackets were made on the two following days.

The results obtained from the laboratory examination were:—

living	131
dead	11
percentage killed ...	7

From the untreated plot no dead Leatherjackets were found.

The percentage killed by this bait is too low to be of any practical value and tests carried out at the Laboratory at the same time show that the bran poisoned with Sodium Fluoride is distasteful to the Leatherjackets.

Paris Green.

Paris Green was then substituted for the Sodium Fluoride and the bait was now made up of 20 lb. bran, 1 lb. Paris Green, water sufficient to moisten the bran (approximately one gallon) per acre.

This dressing was first tested out on half-an-acre of heavily infested Autumn wheat also near Rhoose, Glamorgan. The application was made on March 2nd, and examinations and collections of Leather-jackets were made on March 4th and 5th. Laboratory examinations were made as before and the results obtained were:—

living larvae ...	... 81
dead	... 114
percentage killed ...	... 57

Collections of larvae from other parts of the field showed that almost all the casualties could be attributed to the action of the bait. No difficulty was experienced in keeping Leatherjackets from an undressed part of the field, alive in the laboratory for several weeks.

The field has been examined since on March 11th and on April 16th. The Leatherjackets were almost absent from the dressed portion on the latter date, half an hour's collection only yielding eleven larvae. On March 11th the bran was still to be seen on the surface of the field and dead Leatherjackets were still plentiful, which suggests that the poisoned bran may remain effective for some considerable time after the application.

As these results were considered to be satisfactory, and as Leather-jacket outbreaks were still numerous, it was determined to continue this trial on a larger scale. In all the bran-Paris Green bait has been tested on six farms in different districts of Glamorgan and Monmouthshire with results as below:—

Farm A. Near Rhoose, Glamorgan. Results given above.

Farm B. At Gileston, Glamorgan. Autumn wheat following two years' ley. One acre dressed on April 5th and collections and examination made as before. Result:—

living larvae ...	... 20
dead ...	... 68
percentage killed ...	... 77

Farm C. At Raglan, Mon. Twelve acre field of Spring oats. This crop followed Autumn wheat which had already failed and the oats themselves were badly attacked. One acre of the worst part of the field was dressed as a demonstration on April 21st. A collection of larvae was made two days later. Result:—

living larvae ...	... 11
dead ...	... 131
percentage killed ...	... 92

A collection was also made from the untreated portion of the field. Result:—

living larvae ...	... 82
dead ...	... 22

The field had been heavily rolled with a Cambridge roller on the day before the application was made, which probably accounts for the high percentage of dead on both the untreated and on the treated portion of the field.

By May 14th the farmer stated that the acre dressed, which was originally the worst affected part of the field, was by far the best plot and could be readily picked out from several hundred yards away.

Farm D. Three acre field near Lisvane, Glamorgan. Autumn wheat had failed and the field had been re-sown with Spring oats. These also failed. This was dressed on May 4th with bran-Paris Green bait and collections made on the two following days with results as below:—

living larvae ...	... 10
dead ...	... 77
percentage killed ...	... 88

Farm E. Three acres of Autumn wheat also near Lisvane, Glamorgan, following two year ley, had failed and been re-sown with Spring oats, which were just beginning to come through at the time of the poison bait application. Leatherjackets were very numerous. As many as twelve could be found under some pieces of the old turf. The three acres were dressed on May 8th, 1925, and collections of larvae made on the 10th showed:—

living larvae ...	... 15
dead ...	... 59
percentage killed ...	... 79

Farm F. Field of eleven acres at Raglan, Monmouthshire, following three year ley. The crop in this case was Spring oats, two acres of which showed very severe Leatherjacket damage. These two acres were dressed on May 11th. It was not possible to visit this field following the application, but the farmer examined the field and estimated that about seventy per cent. of the Leatherjackets were killed. The field has since been examined on June 2nd, and the oat crop at that stage was very satisfactory. The damaged areas apparently had not extended.

The results obtained have thus proved to be satisfactory in each case tested and this has been confirmed by the tests carried out by the West of Scotland Agricultural College with the Paris Green bait, an account of which was published[2] whilst these tests were in progress.

The total figures from the whole of the trial were:—

Total number of Leatherjackets collected ...	586
Number apparently normal	137
Number killed	449

Number killed by bait, 77 per cent. approximately.

It should be pointed out that these figures only show the percentage killed within two or three days of the application. In one case mentioned, where the application was made on March 2nd, an examination on March 11th, *i.e.*, nine days later, showed some dead larvae and the poisoned bran was still easily noticeable on the surface of the ground, which suggests that the bait may easily remain effective for quite a long period, and that the effectiveness of the bait is in reality higher than the above figures indicate.

It should also be pointed out that the cost per acre for materials does not exceed 5s., and as the labour involved is very light the treatment would appear to be practicable and quite satisfactory.

Conclusions from the above Tests.

1. Naphthalene has some value as a deterrent against Leatherjacket attack.

2. Kainit has no insecticidal value against Leatherjackets and apparently no value as a deterrent.

3. Sodium Fluoride as a bait poison is not satisfactory, at any rate at the strength tested.

4. Paris Green is a satisfactory poison and if carefully used should prove of considerable value as a control for Leatherjackets. Its value as a control for various Caterpillars is already well recognised in Canada and the United States.

Note.—In view of the Protection of Animals Act, 1911, it appears that the poison bran may only be used where "all reasonable precautions" are taken "to prevent access thereto of dogs, cats, fowls, or other domestic animals." Both for these and other reasons the circumstances in which the treatment is advisable are rather limited and those who wish to employ this control measure will do so on their own responsibility in conformity with the application of the aforementioned provisions to their own case.

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[2] Bulletin No. 103 of the West of Scotland Agricultural College.

THE DOUGLAS FIR IN NORTH WALES.

By Thomas Thomson, M.Sc.,

University College, Bangor.

The Douglas fir, discovered by Archibald Menzies in 1792, was introduced into Britain by David Douglas in 1828, so that it is just under a century since the first trees of the species were planted in this country. Subsequent investigation has shown that the tree has a very wide natural distribution in the west of North America and that considerable botanical and silvicultural differences are exhibited by it in different parts of its range. The specimens originally introduced were from Oregon, and a similar type of tree is found in the coastal regions of Washington and British Columbia. This variety of the Douglas fir has long been known to British Foresters as the Green or Oregon Douglas fir as distinct from the Blue or Colorado Douglas fir, found in the Rocky Mountain region in the interior of the country. The Green form is much the more valuable and its rapid growth and excellent timber, together with its freedom from disease, have won for it an important place in our forest flora. The following notes refer exclusively to this variety.

It is improbable that any specimens of the original consignment are to be found in North Wales to-day, but there are several trees over eighty and perhaps over ninety years old. In Penrhyn Park, Bangor, there are two Douglas firs which are known to be the parents of trees formerly in the Cochwillan Wood, which would have been seventy years old if it had not been felled during the war. These trees are probably between eighty-five and ninety years old. They are situated alongside the main drive from Llandegai and when measured in March, 1924, had the following dimensions:—

	Total Height.	Girth over Bark at breast Height.	Remarks.
No. I.	87ft.	14ft. 1in.	Leader broken off some years ago.
No. II.	99ft.	12ft. 11in.	Two large branches spring from near the base and grow upwards. Girth measured above these.
		Girth of branches 1ft. from stem.	
		6ft. 9in. 9ft. 8in.	

Other old trees are growing at Powis Castle, near Welshpool. The oldest is said to have been planted in 1842 and is 13ft. 2in. in girth at breast height and 135ft. high, with an estimated volume of 429 cu. ft. quarter girth over bark. Near this tree, and standing in a sheltered position beside a small pool, is what is probably the finest specimen of the species in Britain. It was measured in August, 1925, and was 11ft. 6in. in girth and over 160ft. high. It is said to be ten years younger than the other.

At first the trees were naturally grown as specimens under arboricultural conditions and are consequently heavily branched. Later some attempt was made to grow the Douglas fir under silvicultural conditions. The most notable was the Cochwillan wood. referred to above. Seed was obtained from the trees in Penrhyn Park and sown in flower pots. The plants were placed in a meadow alongside the River Ogwen about the year 1854. There were left standing on the ground a number of oaks among which the young trees were planted, but one small enclosure was free from them and a pure crop of Douglas fir was raised which was measured in 1912 and gave the following figures:—

Mean Height.	Mean Quarter-girth at breast Height.	No. of Trees per Acre.	Vol. per Acre Quarter-girth over Bark.
101 ft.	17½ in.	119	11,450 cu. ft.

The trees, having been planted about eighteen feet apart, had developed rather coarse side branches and the quality of the timber would have been better if a closer stand had been maintained in earlier years. The wood was felled during the war.

Fine trees about seventy years old are to be seen at Dulasau, alongside the River Conway between Bettws-y-coed and Pentrevoelas, several being over 115ft. high and 10ft. in girth. These trees are growing among hardwoods, which they, of course, far overtop. The position is a sheltered one with a deep, light loam soil. There are numerous instances of Douglas firs, between forty and sixty years old, growing singly among hardwoods and other conifers. In these cases the Douglas firs have outstripped their companions in height and girth. In situations where the wind is apt to sweep unchecked over the woods the tall isolated crowns of the Douglas firs are almost invariably broken and unsightly, but in sheltered places they retain their leaders and continue to grow steadily in height.

A few measurements of the relative sizes attained by Douglas firs and other species of apparently equal age are given below.

Dulasau Lower Wood, Bettws-y-Coed. Elevation 500 ft. Age about 70 years.

		Height.		Quarter-girth.
Douglas fir (mean)	...	116 ft.	...	29 in.
Spruce (tallest)	...	90 ft.	...	18¼ in.

Bryn Derw, Bethesda. Elevation 350 ft. Age about 60 years.

		Height.		Quarter-girth.
Douglas fir	...	97 ft.	...	19½ in.
Larch	...	—	...	10¾ in.

Moel-y-Ci, Tregarth. Elevation 800 ft. Exposed to east and north east winds. Age 43 years.

		Height.		Quarter-girth.
Douglas fir	...	67 ft.	...	10 in.
Larch	...	59 ft.	...	7 in.

Following the period when the Douglas fir was planted in small numbers scattered among other species, came a time when a number of plantations of common larch and Douglas fir were established. The plants of the Douglas fir were very expensive and had to be made to go as far as possible. On the Llandinam Estate, Montgomeryshire, there are a number of such plantations about thirty-five to forty years old. The practice was to plant in the proportions of one Douglas fir to three to five larches—rows of pure larch alternating with rows of larch and Douglas fir. The planting distance varied in different woods, so that the Douglas firs stood twelve to eighteen feet apart. At the present time the Douglas firs have far outgrown the larches, which in many cases are completely suppressed. This has been the case in the Tyn-yr-wtra plantation, Llandinam, from which the remaining larches were removed about eighteen years after planting. This plantation, growing in a sheltered dingle with light soil on shale, was described in the *Empire Forestry Journal,* Vol. 2, No. 2, Dec., 1923. The volume per acre was 7,470 cu. ft. quarter girth over bark at thirty-eight years of age. It was evident that the trees had not been well cleaned and that the branches had grown to an unduly large size before they were killed off. Other plantations of a similar character are found in the neighbourhood, but generally on less favourable sites. In all cases the killing out of the larch and the very rapid but rather coarse growth of the Douglas firs is evident.

Younger woods containing Douglas fir grown pure and in mixture are relatively common, and its silvicultural requirements are being more generally understood. The most important of them are: shelter from strong and from dry cold winds, a moderately deep,

light soil with a low proportion of lime, an ample supply of moisture but no approach to stagnation, and the arrangement of the planting and after treatment so as to ensure a pure crop of Douglas fir in the end, as the tree will ultimately outgrow any other species associated with it. Pure woods are quite suitable, the canopy is established early, the trees are well drawn up, and the thinning and management are simple. In such woods a planting distance of six feet is close enough. Closer planting is not only expensive in the first place but the thinnings have to be begun early and produce only small material, which may be difficult to dispose of and fail to pay the cost of extraction. Close planting, moreover, does not ensure self-cleaning, and the removal of the dead side branches will be necessary in any case. This should be done with the saw, as, unless great care is taken, bad bark wounds will be made if a bill-hook is used. Pruning with a saw is done by piece work at from £3 to £3 10s. per acre, according to planting distance and local wages rates. The dead branches only are removed up to the height that can be conveniently reached. Later on, when after successive thinnings the number of stems has been reduced and those that are to form the final crop are being selected, these may with advantage be pruned of dead branches to as great a height as can be reached with a pole-saw.

The Douglas fir is primarily a tree suited for the production of large timber. The young poles have a greater proportion of sapwood than those of larch. They are, however, durable when exposed to wind and weather, though it is advisable to creosote the ends of posts inserted in the soil. The poles make better fencing material than any of our conifers, with the exception of larch, but the latter will always be preferred where obtainable. For this reason the growth of the Douglas fir in mixture with larch has certain advantages. The common larch grows faster than the Douglas fir at first, but as a rule the latter overtakes it somewhere between the fifteenth and twentieth years. The Douglas fir maintains its vigour quite well under the thin cover provided by the common larch, whereas the larch will not stand the shade of the Douglas fir, which will ultimately take complete possession of the ground. It is therefore necessary to remove the larches early, and there should be enough Douglas firs to form a canopy without too long a period elapsing during which the individual trees will spread their crowns unchecked by competition. The system adopted in the older woods of using a larger proportion of larch than of Douglas fir led to undue branch development in the latter, and a mixture of equal numbers of the two species at six feet

apart would be better. Fortunately the cost of plants of the two species is now more or less equal. Before the war Douglas fir was about three times as expensive as larch.

A mixture of the Douglas fir with the Japanese larch is not likely to lead to such good results. The Japanese larch not only grows faster in its youth than the European, but it casts a much deeper shade. The Douglas firs become completely overgrown and suffer so much that only a few ultimately win their way to the upper canopy. In some cases a sufficient number may survive to provide a good crop, but the experiment is risky. The difference between the plots of common larch and Douglas fir and Japanese larch and Douglas fir on the Ceiriog experimental area is very marked. At seventeen years of age the Douglas firs in the European larch plot are now becoming the dominant crop, whereas in the other plot the majority of the Douglas firs are suppressed, and drastic thinning of the Japanese larch has been necessary to relieve the rest.

Mixtures of the other common conifers with the Douglas fir are not to be recommended. They will all be suppressed in their youth unless the number of Douglas firs is so small that they will themselves become too wide-crowned. Experiment in even mixture with spruce showed that not a single spruce reached four feet high before being killed, so that the money spent on plants and planting was utterly wasted. In the case of Sitka spruce, however, there may be justification for the mixture in situations which may not be ideal for the Douglas fir. At higher elevations and on heavier soils the Sitka spruce will keep pace with the Douglas fir and satisfactory results may be anticipated. In such cases one would regard the experiment as an attempt to improve a Sitka spruce plantation by the introduction of the more valuable Douglas fir. Where there is reason to expect that the Douglas will grow well there is no advantage in introducing the spruce.

The propagation of the plants in the nursery presents no great difficulties. Good seed can be obtained from the well-known firms and it germinates well. The seed should be soaked in water for twenty-four hours before sowing. Even better results have been obtained by keeping the seed moist until it has begun to germinate and then sowing in a well-prepared seed-bed in early May. The seedlings are left two years in the seed-bed and lined out for one year. Transplants of this kind can be purchased at about thirty-five shillings a thousand, and are quite suitable for land in which there is not a great growth of weeds. Larger transplants may be used where weed-growth is excessive and in well-sheltered situations.

Besides the usual cutting of weeds during the first two or three years it will often be necessary to trim plants which show double leaders. These are apt to arise on account of the habit of the Douglas fir, in favourable localities, of making a second growth in the year. Very often the leading bud does not grow on, while one of the side buds near it may start into growth in August and produce a shoot several inches long. The following year this side shoot has a tendency to maintain its advantage and usurp the place of the true leader. In such cases the less vigorous of the two shoots should be cut off.

The natural dangers to which the Douglas fir is subject are fortunately so far not great. Nevertheless the increased planting of the tree has of recent years been followed by the appearance of certain insect and fungoid pests which were formerly unknown in this country. In common with all the ordinary conifers it suffers from the Pine weevil and the Honey Fungus. The most important specific insect pest is the aphis, Chermes Cooleyi. This appears as white woolly tufts on the needles and twigs under which the insects are found sucking the juices of the plant. Fortunately the damage done is not serious, the tree seeming to recover from the attack, but the insect is becoming more common and is plentiful in parts of North Wales.

Home-grown timber of the Douglas fir has not up to the present been of the same high quality as that from the native habitat of the tree. It is generally wide-ringed and knotty. The rings show a marked zone of hard, red summer wood which makes the timber difficult to work when the rings are wide. It is, however, strong, durable, and handsome in appearance and can be obtained in large sizes. Its defects are due to the way in which it has been grown in the past. Too open a stand in early years has promoted the production of broad rings and large branches. With better treatment, particularly in the direction of providing greater competition between the trees in their youth, and gradually opening up the crop later, there is every reason to believe that the defects at present associated with the home-grown timber of this valuable species will be eliminated.

ABSTRACTS, REVIEWS, AND BIBLIOGRAPHICAL NOTES.

ANIMAL NUTRITION.

Cattle Feeds; Digestion Experiments with.

J. B. LINDSEY, C. L. BEALS, P. H. SMITH and J. G. ARCHIBALD. *Massachusetts Agric. Expt. Station Bull.*, No. 216.

Results are given of digestibility studies on fourteen different materials. The experiments which are reported cover a period of four years. It is pointed out that the coefficients of digestibility obtained with some feeding stuffs vary considerably according to circumstances. In some of the experiments quite wide variations are observed for which no satisfactory explanation can be given. It is suggested that bacterial activity in the intestinal tract was more pronounced in some cases than in others.

J.J.G.

Calves; Milk Substitutes in the rearing of young.

J. B. LINDSEY and J. G. ARCHIBALD. *Massachusetts Agric. Expt. Station Bull.*, No. 223.

The bulletin presents the report of seven different feeding trials with forty-five different animals. Various milk substitutes were used and special efforts were made to provide variety and completeness of protein, abundance of vitamines and a sufficiency of mineral matter, but, on the basis of growth produced the skim-milk lot did much better than any of the others. The final conclusion appears to be that much more investigation is needed in order to decide upon the nature of the materials best suited for making up an ideal milk substitute for calves. J.J.G.

Ensiling; The Food Value of Ensilage and the Economy of.

E. J. SHEEHY and D. DELANEY. *Journ. Dept. of Lands and Agric., Irish Free State.* Aug., 1924, 117—139.

Experiments carried out at the Agricultural Station, Athenry, show that ensilage appears to have a higher value when fed in moderation than when given in large quantities. The ration of yearling calves may safely include twenty-one pounds and that of fattening cattle and milch cows about forty-two pounds per head daily of good ensilage. It was found that the total food produced per acre was less in the case of ensilage than of mangels, but the cost of producing equivalent food values of each worked out at the same figure. In the case of ensilage consisting of a mixture of cereal and leguminous plants, it was shown that five-and-a-half pounds was a safe figure to be adopted as the weight of ensilage of equivalent food value to ten pounds of mangels. J.J.G.

Fattening Pigs; The Value of Green Food for.

E. J. SHEEHY. *Journ. Dept. Agric. and Tech. Inst., Dublin.* May, 1924, 28—41.

In a number of pig feeding experiments it was found that only a small quantity of green food could be economically substituted for part of either the separated milk or meal portion of a pig's diet. It is indicated that

the value of green foods for pigs is limited by the nature of the pig's digestive organs and by the deleterious effects of green foods on the bacon. Where green food "is made to constitute part of the ration of fattening pigs the feeding of it should be discontinued for a considerable time prior to the slaughter of the animals." J.J.G.

Milk Cows; Steamed Bone Flour as a Mineral Supplement for Milk Cows.

A. C. M'CANDLISH and R. A. BERRY. *Scottish Journ. of Agric.* Jan., 1925, 55—57.

The inclusion of steamed bone flour in the ration had no marked effect on the yield of milk, neither was the butterfat content appreciably influenced. J.J.G.

Variations in the Quantity of Food required by Cattle for Maintenance and Fat Production with different kinds of rations.

J. WILSON. *Sci. Proc., Royal Dublin Soc.* May, 1925, 77—91.

The author discusses in detail the method adopted by Kellner to ascertain the extent to which a bullock's ration is utilised for maintenance. It is shown that Kellner made the working assumption that a bullock needs no more for maintenance when putting on fat than when idle. Kellner also made the unqualified assumption that no more food is used for maintenance with a less than with a more tractable ration.

The author points out, however, that when an animal is putting on fat he consumes more food and, therefore, more energy may be spent in its disintegration and manipulation, and additional energy may be spent in repairing the organisms and keeping it working. J.J.G.

Mineral Metabolism of Farm Animals; Some Aspects of the

W. GODDEN and A. D. HUSBAND. .*J. Soc. Chem. Ind.* July 3, 1925, 671—674.

Attention is drawn to the importance of the economic aspect of mineral nutrition in the case of animals. Some of the symptoms of mineral deficiency are described. Special references are made to the requirements of animals in lime, phosphoric acid, iron, chlorine and iodine. Factors which influence the assimilation and utilisation of minerals are mentioned. e.g., sunlight, housing, exercise, acid:base ratio of the food, and probably a ratio of organic to inorganic constituents. It is suggested that these factors "exert their greatest beneficial influence in the case of a badly balanced ration or one in which none of the minerals are present in adequate amounts." J.J.G.

Pigs; Wet versus Dry Feeding for.

J. P. DREW. *Journ. Dept. of Lands and Agric., Irish Free State.* Aug., 1924, 99—102.

The results obtained in four experiments indicate that "no better results may be expected from feeding the meals dry than from feeding them mixed with water in the ordinary way." J.J.G.

Protein Requirement; The Minimum—for Growing Dairy Heifers.

W. W. SWETT, C. H. ECKLES and A. C. RAGSDALE. *Missouri Agric. St. Research Bulletin* 66.

An account is given of experimental work extending over approximately 7½ years. The rations were arranged to provide energy equal to or slightly

in excess of that recommended by the correct feeding standards, and an adequacy of mineral salts and vitamines. The amounts of protein in the diet were varied from very low to very high planes. The interpretation of the results have been based more upon the development and behaviour than upon the nitrogen balance of the animals. Generally speaking, an increase of protein in the ration was accompanied by an increase in percentage of normal growth in weight and by a smaller increase in percentage of normal skeletal development.

The results of these investigations indicate that the Wolff-Lehmann and Armsby protein standards appear to be from 20 to 25 per cent. and from 50 to 60 per cent. higher, respectively, than is necessary for the promotion of normal growth in weight. As protein is usually the most expensive constituent of rations the possibility of a considerable saving is thus indicated. J.J.G.

Silage (Rye Grass and Clover); The Nutritive Value of Stack.

H. E. WOODMAN. *J. Agric. Sci.*, 1925, 15, 327—333.

A digestion trial with sheep showed that in producing "sweet" stack silage from a crop of ryegrass and clover there was an appreciable depression of the digestibiilty of the crude-protein of the crop. Less than half of the dry matter was digested and utilised by the animal. It is suggested that the low protein digestion co-efficient was due to the high temperature attained in the stack. J.J.G.

Vitamin A; The Influence of Storage and of Emulsification on the—in Cod Liver Oil.

J. C. DRUMMOND, S. S. ZILVA and K. H. COWARD. *J. Soc. Chem. Ind.* July 18, 1924, 236T—238T.

Investigations were carried out with various samples in order to determine the influence of storage and emulsification. The results show that the oil may lose a considerable proportion of its vitamin A value when stored under conditions that permit oxidative changes. J.J.G.

Vitamin A; The Quantitative Determination of.

H. C. SHERMAN and H. E. MUNSELL. *J. American Chem. Soc.* June, 1925, 1639—1646.

For the quantitative determination of the relative vitamin A content of foods it is recommended that young albino rats of known nutritional history be placed upon a diet which is free from vitamin A but adequate in all other respects. Subsequently the rats are divided into groups. One group is continued on the basal vitamin-A-free diet as a "negative control." The other group receives graded portions of the food to be tested. The minimum allowance of food which will induce an average gain in weight of 3g. per week during the test period is thus ascertained.

The unit recommended for numerical expression of results is that amount of vitamin A needed daily in order to give an average gain of 3g. per week in a standard test animal.

The choice and control of the basal diet, of the test animals, and of the experimental procedure, together with the interpretation of the results, are discussed. J.J.G.

Vitamin A; Quantitative Experiments upon the Occurrence and Distribution of—in the Body, and the Influence of the Food.

H. C. SHERMAN and L. C. BOYNTON. *J. American Chem. Soc.* June, 1925, 1646—1653.

Under the conditions of the experiments with rats it is shown that the kidney is at least forty times as rich as the muscle; the lung more than forty times, and the liver from 200 to 400 times, as rich in vitamin A per grain as muscle.

The vitamin A content of the food influences that of the body.

J.J.G.

Vitamin Value; The Relation of Manure to the Nutritive Value and—of certain Grain.

R. McCarrison. *British Medical Journal.* March 29, 1924, 567.

Feeding experiments were conducted with grain obtained from the plots which varied in their manurial treatments. It was found that the grain obtained from the plot which had been continuously treated with cattle manure appeared to have a higher vitamin B value than the others.

J.J.G.

CROPS AND PLANT BREEDING.

Barley; Inheritance in. II, The Awn and the Lateral Floret.

F. L. Engledow, M.A. *Journ. Agr. Sci.*, 1921, 11, 159--196.

A series of crosses in each of which an awnless two-rowed barley (*Hordeum distichum inerme*) was used as one of the parents have been studied. The other parents were: *H. hexastichum* (var. Praecox), *H. hexastichum* (v. parallelum), *H. intermedium* (var. Haxtoni), *H. distichum* (awned, Russian Chevallier No. 6), *H. distichum* (awned, Russian Chevallier No. 7), *H. distichum* (awned, Russian Goldthorpe No. 9), *H. distichum* (awned, Plumage).

Considerable fluctuation in awn development is found even when early and late inflorescences of the same plant are compared. Considerable difficulty was in some cases experienced in distinguishing between different types, and to such an extent in one case that the author himself found his F_2 results gave a very close agreement with "expected" results on the basis of tri-hybrid segregation. Further work, however, brought even this family into line with his other results. "The general conclusion from the experimental evidence which has been recorded is that the presence of full length awn is due to the homozygous presence in the plant of one factor; the intermediate or half-awn corresponds to the heterozygous presence of the factor; the absence of the awn to the absence of the factor."

The study of "fertility" in the lateral floret is difficult, but from the results here recorded and discussed "the main conclusions are that 'fertility' of the lateral floret segregates on a 1:2:1 basis. In *H. hexastichum* crosses it is inseparable from 'full awn,' whereas in *H. intermedium* crosses this is not the case. Relatively long glumes are inseparable from 'awnlessness' and conversely; while, finally, dense-rachis is similarly inseparable from a large palea (lateral floret)." T.J.J.

Cereals; Investigations on Yield in the. I.

F. L. Engledow, M.A., and S. M. Wadham, M.A. *Journ. Agr. Sci.*, 1923, 13, 390—439; *Journ. Agr. Sci.*, 1924, 14, 66—98; *Journ. Agr. Sci.*, 1924, 14, 287—324; *Journ. Agr. Sci.*, 1924, 14, 325—345.

"The cereal 'yield problem' embodies all the possibilities of increasing the output of grain per unit area. Part I is devoted to a general

consideration of these possibilities category by category." Amongst the factors controlling yield is placed botanical variety or form, and methods of obtaining new varieties are discussed. In the past, eye judgment has been largely used in selection, but it would be a great advantage if some simple "index" of yielding capacity applicable to the single plant or to very small populations could be found.

In Part II an extensive, or rather an intensive, study of pure lines of the two barley varieties, Plumage and Archer, is recorded. The two varieties were studied from germination to maturity, elaborate precautions being taken that, with the populations available, comparisons of one and the same variety at different times, and of the two varieties at the same time, should be as reliable as possible. In length of coleoptile and in length of first leaf the two varieties differ distinctly, and in their case it is found that "first-leaf length is a far better index of 'variety' than is dry weight," at least in the early growth stages. The two varieties also differ in type of root system. "In Archer the seminal system is from the outset more abundant and extensive than that of Plumage. On the other hand, Plumage more speedily elongates its adventitious roots." After a study of ear characters, it is found that "there is full reason for concluding that the total weight, the number of grains, and their ratio are, for yield analyses, the only experimental ear attributes." A study of the "average ear" shows that "Plumage characteristically has relatively larger grains at the base and tip of the ear than has Archer," and "it is suggested the average ear is one of the attributes upon which the selection of small populations, e.g., F_3's and F_4's, should be based." High tillering capacity is not necessarily an index of high yielding capacity, since there is a concomitant rise of average grain weight and number of grains which implies "that an ear of twenty-four grains is certain to weigh more than two ears each of twelve grains." It is possible that, owing to drought, inherent differences in tillering capacity as between the two varieties failed to find full expression in 1921, but it would appear that such differences are in any case small under the conditions of the experiment.

In the same plant "flowering time" of the second and third tillers is related to that of the first, but it would appear that these relationships are different for the two varieties studied. A slight initial advantage in the development of the plant is maintained up to the flowering stage in the case of the main tiller, so that one plant which on a certain date consists of four leaves and one tiller will come into inflorescence before another plant which at the same date consists of three leaves and no tillers. This and other evidence suggest the use of modal plants in sampling.

With the greatest possible care in sampling, with a view to making plants comparable, there still remain plant to plant fluctuations, and, as regards yield, there is no necessary correlation between the various tillers of the same plant. ". . . . it has to be concluded that, full precautions notwithstanding, the chance of reliably determining yield per plant from small samples is a remote one."

". . . . for plants of the same chronological age, the percentage contents of nitrogen and ash show wide fluctuations," so that for reasonable reliability "far larger populations and far larger samples" than those available would be required. ". . . . the five variables—dry weight, nitrogen per cent., ash per cent., chronological age, and number of tillers —appear to show no regular inter-relationships.

Per plant, there is greater correlation between weight of grain and number of grains than between weight of grain and any one of the following variables—straw weight, number of grains per tiller, individual grain weight, and migration co-efficient, and the correlation of total grain weight to each of these decreases in the order given. ". . . . a high value of *n* (number of grains) seems the prime essential to a high value of G (weight of grain), whether per plant or per acre."

When a population is subdivided into groups on the basis of number of ears per plant, it is found that, applied to the various groups, the migration co-efficient remains more constant than yield of grain. At the same time, wider spacing of plants affects straw yield more than grain yield, so that relation of grain to straw is dependant upon the spacing of the plants. "For the single plant, it appears impossible to represent G (total grain weight) as a function of one or a combination of the other plant variables explored."

Based upon these investigations, a scheme for small-scale cereal yield trials is developed in § XII.

A résumé of the whole work is given in Part III. T.J.J.

Crop Production in India; A Critical Survey of its Problems.

ALBERT HOWARD, C.I.E., M.A. *Oxford University Press.* 1924, pp. 1—200.

It is a far cry from Wales to India, and the agricultural conditions and methods of crop production adopted in the two countries combine to represent almost the extremes of farm practice. The appearance of the book before us is nevertheless an event of first rate importance to the thoughtful agricultural student of our home Colleges who desires to enter upon a career of research no less in the Mother Country than in the outposts of Empire.

One, and perhaps not the least important, effect of the author's far-sighted treatment of his subject must inevitably be to stimulate a spirit of enquiry, and to assist in the direction of agricultural research along lines most hopeful of economic benefit. The immense scope that exists for brilliant investigation is brought out again and again in almost every chapter of the book and should make a strong appeal to the reader with imagination—an appeal which can hardly fail to fire student readers possessed of enterprise and ambition with a desire to seek their fortunes amongst the vast agricultural problems calling for solution in distant lands.

The problems dealt with are essentially Indian problems, and the crops dealt with are, of course, Indian crops. Twelve of the twenty-one chapters are, however, devoted to matters of general interest which are discussed from so wide, and so different, a point of view to that taken up in the generality of agricultural books as to provide food for thought to agriculturists of all countries alike.

In Part I—The Soil—the plant has been regarded as the centre of the subject and the various soil factors—surface drainage and erosion, soil aeration, the nitrogen problem, and the like—have been considered strictly in relation to the welfare of the crop.

In Part II—The Crop—from the general reader's point of view, will be found some of the most interesting chapters of the book. The angle from which the author largely deals with this aspect of his subject is well indicated by the following quotation from the introduction to this section, viz.:—

"Two conditions must be satisfied in the work of crop improvement. The first is an adequate realisation of the working conditions of the average cultivator, so that all proposals for his benefit may be practicable. The second is the need of a thorough study, at the Experiment Stations, of the problems to be attacked. Anything brought to the notice of the people should be the best that can be devised in the present stage of knowledge. A constant succession of new varieties or frequent modifications of some process already introduced only bewilder the cultivator and tend to lower the confidence of the public in the work."

The importance of the root systems of all agricultural crops and the factors influencing root development are dealt with in a separate chapter and is a theme continually recurring throughout the book. It is not unlikely that the question of root system may assume a greater importance under certain Indian conditions than in this country, but the stress laid on the obvious significance of difference in root system as between plant and plant and species and species is a timely reminder of an aspect of crop production which has been much neglected by investigators in general.

Disease in plants is dealt with in a striking chapter, and incidentally throughout the book. The relation of conditions to disease is demonstrated by a number of interesting examples. We are informed that the experience of the sugar planters of Java falls in with the view that "resistance to disease is partly a consequence of efficient gearing, and that attacks of parasites only follow mistakes in the choice of varieties or in agricultural treatment." It is suggested that the time may come when parasites will be regarded not so much as pests to be destroyed but as very valuable indicators for checking the procedure of the agriculturist.

The book closes with two short chapters on the organisation of research.

An adequate index is provided and a selected bibliography has been appended to each chapter. R.G.S.

Crop Variation; Studies in. I. An Examination of the Yield of Dressed Grain from Broadbalk.

R. A. Fisher, M.A. *Journ. Agr. Sci.*, 1921, 11, 107--135.

From a study of wheat yield on thirteen plots which have been under uniform treatment in Broadbalk field, Rothamsted, from 1852 to 1918, three types of variation are distinguished. (1) Annual variation, due primarily to the weather, either directly or indirectly. (2) Steady diminution, due to deterioration of the soil, which may vary in character from plot to plot; and (3) Slow changes other than steady diminution.

Only the dunged plot appears to have suffered no deterioration, although the mean yield for "complete artificials" is somewhat higher than that for the dunged plot. In the last twenty years the former plot has given the heavier average yield.

"The comparative yields of . . . four (of these) plots have become the standard example of diminishing results in agriculture," but the evidence of recent years shows that in fact the benefit from the heavier dressings "was not wholly reaped in the immediate yield, but to some extent is long effective in maintaining the fertility of the soil at a higher level."

From comparisons made it is concluded that the causes of the slow changes other than steady diminution were located in Broadbalk itself, and evidence is found that these changes, at least to a great extent, are due to weeds.

"One point of importance . . . is that average wheat yields, even over long periods, from different fields, or for different seasons, cannot approach in accuracy the comparison of plots of the same field in the same seasons." T.J.J.

Crop Variation; Studies in. II. The Manurial Response of Different Potato Varieties.

R. A. Fisher, M.A., and W. A. Mackenzie, B.Sc. *Journ. Agr. Sci.* 1923, 13, 311—320.

A statistical study of results obtained with twelve potato varieties and six schemes of manuring, from which it is concluded that

"(1) The data show clearly significant variation in yield due to variety and to manurial treatment.

(2) There is no significant variation in the response of different varieties to manure.

(3) The yields of different varieties under different manurial treatment are better fitted by a product formula than by a sum formula.

(4) For the purposes of analysing the variation the product formula may be obtained by successive approximation from" two equations given; "the exact method of solution should not be necessary in any ordinary case." T.J.J.

Crop Variation; Studies in. III. An Examination of the Yield of Dressed Grain from Hoos Field.

W. A. Mackenzie, B.Sc. *Journ. Agr. Sci.*, 1924, 14, 434—460.

A statistical study of barley yield under various systems of manuring is made. For most of the plots under consideration the whole period, 1852—1921, comes under review.

"Of the three sources of supply of nitrogen (Rape cake, ammonium salts, nitrate of soda), rape cake gave the highest mean yields in the absence of superphosphate, while nitrate of soda gave results significantly better than those obtained for ammonium salts."

Superphosphate both increases barley yield and assists in maintaining the fertility of the soil; while "sulphate of potash seems to have an adverse influence upon the barley yield."

"The deterioration of barley plots is much heavier than in the wheat plots." "Barley is more variable than wheat and is more subject to the influence of meteorological conditions." T.J.J.

Development of the Wheat Grain; A Chemical Study of the.

H. E. Woodman, Ph.D., D.Sc., and F. L. Engledow, M.A. *Journ. Agr. Sci.*, 1924, 14, 563—586.

T.J.J.

Electro-Culture; Field Experiments in.

V. H. Blackman. *Journ. Agr. Sci.*, 1924, 14, 240—267.

"Four years' additional experimental work on the application of a high tension discharge to the growth of field crops is described."

Fourteen out of eighteen experiments with various crops have given

"positive results in favour of the electrified plots," while the remaining four showed a decreased yield as compared with control plots. "Nine show increases of 30 per cent. and over, some reaching 50 per cent." The main increase in yield for spring-sown oats and barley was 22 per cent. "A beneficial effect of the discharge on clover hay is probable, while the effect on winter-sown wheat is still uncertain." T.J.J.

Field Experiments.

R. A BERRY, Ph.D., F.I.C., and D. G. O'BRIEN, M.A., B.Sc. *Journ. Agr. Sci.*, 1924, 14, 407—412.

Field experiments with oats, carried out over many seasons in the West of Scotland College area, are brought under review.

The trials consisted of a single plot of each variety at each centre, and from all the results taken together it is concluded that under these conditions the probable error for the old Scottish varieties is about 18 per cent. of the yield of grain, and for the "newer varieties" about 20 per cent. This means that in order to identify a difference in yielding capacity of 5 per cent. with a single year's trial 214 centres would be required on the single plot basis. "When the difference is likely to be about 10 per cent. it would be necessary to have fifty-three centres." T.J.J.

Forms and Strains of Trifolium repens L; Experiments and Observations on.

W. M. WARE, M.Sc. *Journ. Agr. Sci.*, 1925, 15, 47—67.

Different plants of white clover (agg.) differ quite markedly from each other when grown under identical conditions. Such variation occurs in size and shape of leaf, character of petiole, spreading capacity, time of flowering, and cyanogenetic properties. The same plant grown under different conditions shows a considerable range of variation, particularly in such characters as size of leaf, length of petiole and spreading capacity, but there appears to be no change in cyanogenetic properties.

Both cyanogenetic and acyanogenetic types occur in old pastures, and cyanogenetic plants under open pollination conditions have given about 75 per cent. progeny plants agreeing in this character with the female parent. The character has not been found to be correlated with any one of the morphological characters studied.

Various types have been found to be inter-fertile, but practically no positive results were obtained by two methods of self-pollination.

T.J.J.

Maize Silage. I.

H. E. WOODMAN, Ph.D., D.Sc., and A. AMOS, M.A. *Journ. Agr. Sci.*, 1924, 14, 461—468.

Discussing the question of "the loss of dry matter sustained by green maize when converted into silage," it is suggested that the variety usually grown in this country, viz., American Horse-tooth, is possibly not the most suitable for our conditions, and that earlier varieties, such as Saltzer's North Dakota, Longfellow, Compton's Early, and White Cap, may be found more useful. T.J.J.

Plant Life on East Anglian Heaths.

E. PICKWORTH FARROW, M.A., D.Sc. *Cambridge Univ. Press*, 1925, pp. x, + 106.

There is no branch of Pure Botany of greater significance to the agriculturist than Ecology, and this is particularly so in relation to all the

problems connected with the management of grass land. It is unprofitable to undertake investigations on grassland unless the problems are looked at from an ecological as well as from a purely practical point of view. Whether it be manurial trials or seeds mixture experiments, we are dealing with highly complex plant communities which are peculiarly sensitive to the inter play of innumerable factors.

Of the wealth of recent ecological work which the agricultural botanist cannot afford to ignore, that of Dr. Pickworth Farrow on the East Anglian Heaths of Breckland deserves special consideration; and the appearance of his suggestive papers published in book form should be particularly welcome to those agriculturists who are unable to keep themselves in touch with current ecological periodicals.

The outstanding lesson taught by Dr. Farrow is the importance of the biotic factor—in agricultural language the influence of the grazing animal—and this lesson loses nothing in its economic implications because the animal under study was the rabbit, and because the vegetation, from an agricultural point of view, was to all intents and purposes valueless.

Perhaps Chapters III, V and X are of the greatest interest to the agriculturist. Chapter III deals with the effects of rabbits on various associations and on individual plants, and the evidence brought forward carries complete conviction largely because it is supported by experiments conducted with the aid of rabbit proof cages. The following suggestive paragraph is quoted from this chapter. "Ecological factors are sometimes grouped solely as climatic or edaphic, but the highly important biotic factors which are capable of exerting such great influence upon vegetation should probably always be included in the classification. . . . Apparently the presence of rabbits alone is sufficient to change the dominant vegetation of Breckland, where *Pteris* is absent from pinewood, through *Calluna* and *Carex arenaria* associations to dwarf grass heath." It must not be lightly assumed that differences in vegetation are necessarily due to differences in soil—it may be more true in some instances to say that differences in the water content and other properties of soil may be due to differences in the vegetation—which difference in the last resort may have been due to the prolonged operation of the biotic factor.

In Chapter V interesting observations are made relating to the competition between plants, and in this chapter the influences of the biotic factor are again abundantly demonstrated. Here the inter-relation of *Juncus squarrosus* and *Agrostis alba* are discussed in relation to rabbits, and in a manner that provides food for thought relative to the different effects of Italian Rye Grass on Red Clover, and smaller grasses according as the sward is allowed to grow luxuriantly and on to hay or is kept closely grazed. The very great importance of tall and luxuriant growth of the aerial portions of plants, from the point of view of ultimately successful competition and the extermination of competitors, is clearly demonstrated. Our author insists on the ecological importance of this fact—a fact which is perhaps of even greater agricultural importance. Instance the marked difference between the flora of waste places and meadows and the equally great difference between that of meadows and pastures. The trend of competition is entirely altered if by grazing a dense and tall smothering canopy is never allowed to develop. Thus in waste places Tall Oat Grass is often very abundant and often practically the only grass present, while

on pastures heavily grazed this competitor with the closer growing bottom grasses is itself eliminated by the operation of the biotic factor.

In his closing chapter Dr. Farrow has very shrewd things to say about general ecological research—remarks which apply almost in their entirety to many aspects of current agricultural research. In the paragraph quoted below (the italics are our own), for instance, the word "agricultural" might be substituted for "ecological" without doing an injustice to Dr. Farrow and perhaps with salutary effect on some of the trends of modern agricultural science:—"Instead of attempting to deal with *ecological* problems in the laboratory where very many factors are varied from their natural values, so that they are liable to alter or modify the result of the experiment unknown to the experimentalist, it is probably much better to take the experimental methods to the plant in its home. *Ecology* means the study of organisms in their homes and the various theories relating to the actual *ecological* problems should be tested by experiments in the field itself, only altering one test factor at a time, and thus getting results definitely related to the effect of that factor upon the organisms, all other factors remaining at their natural values."

The letterpress is supported by forty-six excellent photographs and by a number of descriptive diagrams. An adequate index is also provided.

R.C.S.

Pot-Culture Experiments with an Electric Discharge.

V. H. BLACKMAN and A. T. LEGG. *Journ. Agr. Sci.*, 1924, 14, 268--286.

Wheat, barley and maize were used in these experiments and "of twenty-eight sets in which the cultural conditions were satisfactory, twenty-three showed an increased yield." "Electrification of barley for the first month of the growing season appears to be as effective as electrification during the whole growing season." Some evidence has been obtained to show that the effect on barley may be differential since in one experiment the increase in grain yield was greater than the increase in total dry weight.

T.J.J.

Potatoes; Genetic Studies in Sterility.

R. N. SALAMAN, M.A., M.D., and J. W. LESLEY, M.A. *Journ. Agr. Sci.*, 1922, 12, 31—39.

In spite of a leading statement to the contrary, the evidence of the results under discussion goes to show that male-fertility in the potato is recessive to male-sterility. It is therefore not considered surprising that Edgecote Purple, which itself is fully male-fertile should give selfed progeny which are also male-fertile, nor that when this variety is crossed with Myatt's Ashleaf (another fully male-fertile variety) the F_1 progeny are male-fertile.

Complications arise when either of these two is used in crosses with Edzell Blue, a variety in which "the male organs are fertile but not fully so." Used as a female parent with either Edgecote Purple or Myatt's Ashleaf, this gives both male-fertile and male-sterile F_1 progeny, but the reciprocal cross with Edgecote Purple as the female parent gives only male-fertile F_1 plants.

It would therefore appear that "the eggs of Edzell Blue are of two kinds, some—possibly half— carrying male sterility, the remainder carrying male fertility," while "the pollen on the other hand all carries fertility."

The discussion of the cause of this difference is left somewhat open owing to the fact that results for presumably selfed progeny of Edzell Blue do not exactly tally with an explanation suggested. T.J.J.

Potato Yields; The Determination of the Best Method for Estimating—together with a Further Note on the Influence of Size of Seed on the Character and Yield of the Potato. III.

R. N. SALAMAN, M.A., M.D. *Journ. Agr. Sci.*, 1923, 13, 361—389.

Results obtained in 1922 indicate that for potato trials the number of tubers per plot should not be less than fifty and need not be more than one hundred, but such a plot should be replicated not less than five times and need not be replicated more than ten times. The plot should be long and narrow rather than short and broad, but care should be taken that the length of the plot is transverse to the greatest variation in soil so that each type of soil is represented in each plot.

The results, as in previous trials, show that the larger the size of the tuber set the higher the gross yield. As the sets are made smaller, the fall in yield is at first slow, but later more rapid. On the other hand, the crop obtained from the smaller sets contains a higher proportion of ware tubers than do other crops, so that when a valuation is placed on the crop. the highest net return is this case is shown from tuber sets of 1 oz. weight Seed of this weight and below, however, may contain a relatively high proportion of tubers affected with such diseases as mosaic, unconsciously selected, so that the minimum safe weight is considered to be 1.5 oz. per tuber set.

Again, remarkably good results are recorded for outgrowths used as sets. These are probably better than entire tubers of similar size in that they produce an equally high proportion of ware while at the same time they are less likely to be disease infected. T.J.J.

Wheat Plants; An Investigation upon certain Metrical Attributes.

F. L. ENGLEDOW, M.A., and J. P. SHELTON. *Journ. Agr. Sci.*, 1922, 12. 197—205.

In the study of the inheritance of glume length in wheat, it was found that fluctuation due to size and vigour in the individual plants resulted in an overlapping of genotypes. It therefore seemed desirable if possible to eliminate this vigour effect by finding a standard in place of the actual figure for comparison. This might reasonably be expected to occur in the ratio between glume length and rachis length. It was in fact found that a correlation between these two characters does exist, but it was also found that unfortunately "the ratio of these two qualities has about as big a co-efficient of variation as the absolute glume length," so that "the ratio appears to be of no special value in investigation."

Evidence is produced which shows that when such characters are studied it is advisable to confine attention to the main stalk of each plant. and further, that in the same set of determinations, only plants producing the same number of tillers should be used.

Variation in size of seed used for planting did not influence the results as determined by glume length, rachis length and the ratio of these two in any observable degree, and selection of seed of a uniform size is not capable of materially reducing fluctuation in these characters.

T.J.J.

Winter Wheat Plants; Colloidal Properties of—in Relation to Frost Resistance.

ROBERT NEWTON, Ph.D. *Journ. Agr. Sci.*, 1924, 14, 178—191.

By mechanical and other methods, the characteristics of winter-hardy and other wheats are studied. It is found that under relatively high pressures, winter-hardened leaf material from hardy varieties retain more moisture than similar material from non-hardy varieties. "The volume of press-juice obtained per 100 gm. of hardened leaves was inversely proportional to the hardiness of the variety," but "the moisture content of hardened tissues tends to be inversely proportional to hardiness."

T.J.J.

Yellow Rust; The Mendelian Inheritance of Susceptibility and Resistance to (*Puccinia glumarum* Erickss. et Heun.) in Wheat.

S. F. ARMSTRONG, B.A., F.L.S. *Journ. Agr. Sci.*, 1922, 12, 57—96.

From very extensive evidence it is shown that immunity to Yellow Rust behaves as a recessive and that 25 per cent. of the F_2 plants obtained from a cross between susceptible and immune breed true to the immune character.

At the same time, "a plant's predisposition or resistance to attack is subject to greater or less modification from the interaction of various other causes." These causes "probably include any factor which is capable of modifying a plant's metabolism to an appreciable extent and embrace

(*a*) Inherited factors leading to fresh combinations of morphological or physiological features, and

(*b*) Non-inherited environmental factors."

It would seem probable that while in this way strains may be obtained which are more susceptible even than their susceptible progenitor, strains may also be obtained in which immunity has reached even a higher standard than in the other progenitor. T.J.J.

Yield of Potatoes; The Influence of Size and Character of Seed on the.

R. N. SALAMAN, M.A., M.D. *Journ. Agr. Sci.*, 1922, 12, 182—196.

Results obtained in the abnormally dry season 1921 support those obtained in the more normal season 1920.

It is shown "that taking into consideration the total weight of seed used, the proportion of heavy ware produced and the total yield, sets of 2 ozs. in weight are the most remunerative." Sets of similar weight but carrying secondary outgrowths are actually more productive and give a higher proportion of ware. It is suggested that this may be correlated with the immaturity of the seed tuber.

"There is no correlation between the presence of secondary growth in the seed set and the existence of the same in the resultant crop."

T.J.J.

ECONOMICS.

ACCOUNTS AND COSTS.

Work of the Agricultural Economics Institute.

C. S. ORWIN, Agricultural Economics Institute, Oxford.

A very pleasant and attractive summary of work attempted and done by this Institute since it was established in 1913. Contains many tables and figures which summarise results of research. A very useful summary to possess; but, naturally, it cannot do complete justice to all the work and projects in forty pages. A.W.A.

Cost Accounts for Three Years.

A. Bridges, B.A., with an introductory note by James H. Ismay.

The booklet contains twenty-three pages of text with twenty-nine pages of accounts and tables dealing with the financial results and costs of milk, crops, etc., on Iwerne Minster Home Farm between (Michaelmas) 1920 and 1923. The text is lucidly written and the analysis of results in the text is clear and precise. Some of the statements of costs in the Appendix are rather unsatisfactory, but Mr. Bridges was not responsible for the lack of adequate detail. In the statement and assessment of results insufficient allowance is made for the effect of purchase and subsequent valuation of pedigree stock. Building up pedigree herds and flocks is a more speculative business than ordinary farming and the complete results, whether good or bad, often require a longer time to develop. A useful study of farm finance during the recent "depression." A.W.A.

An Economic and Financial Analysis of Fourteen East Anglian Farms in 1923—24.

J. A. Venn, M.A., School of Agriculture, Cambridge.

The group of farms consists of four on "heavy," four on "medium," and six on "light" soils. Two of the "heavy" farms made profits, and two losses, but the two with profits were small holdings. All the "medium" farms and all but one of the "light" farms made some profits. The average "net returns" as percentage of capital was 4.6 % on heavy land, 10.6 % on medium land, and 6.1 % on light land, with a true average of 4.4 % on all the farms, including and allowing for the three which suffered losses. Tabular statements of costs and of other data are given. A very useful report, but some of the "averages" in the Tables should be used with caution. They are of the simple variety. A.W.A.

Scientific Farm Management.

James Wyllie. *Transactions of the Highland and Agricultural Society,* 1925; and reprinted.

A paper showing a method of stating and assessing the financial results of farm management. It will be useful to anyone concerned with the interpretation of book-keeping results to farmers or would assist farmers to understand the practical uses to which accounts may be put. A.W.A.

Agricultural Book-keeping in Denmark.

Edgar Thomas, B.A., *Scottish Journal of Agriculture,* October, 1924 (reprinted).

Agricultural Costings in Switzerland and Denmark.

A. G. Ruston, D.Sc. *Journal of the Ministry of Agriculture,* August, 1925 (reprinted).

Both these papers were written after visits to Denmark and Switzerland. They are complementary to each other, though not in any way connected. The first deals with methods rather more fully than the second, which is mainly concerned with results. They are of value in showing the advanced state of development of farm book-keeping in these two countries, and the social and individual value of the information obtained. Some of the data is useful for purposes of comparison with results of economic organisation of agriculture in this country. A.W.A.

AGRICULTURAL ECONOMICS; TEXT-BOOKS OF.

Agricultural Economics.

L. C. Gray. Published by Macmillan & Co., 1924.

A very useful text-book of Agricultural Economics. It is thoroughly American, but many of the problems which it treats are found in almost exactly the same form in this country. The methods of study of or attack on problems are often the same in both countries, as may be seen by a comparison of some chapters of this book with recent British work. Some of the principles enunciated have to be considered and even applied in this country. As the study of Agricultural Economics has been long established in U.S.A. and much experience gained in investigation, demonstration and teaching, American literature is useful for suggestion if not for dogmatic instruction. A.W.A.

Practical Farm Economics.

H. C. Taylor, H. R. Tolley and J. W. Tapp. *U.S. Department of Agriculture Miscellaneous Circular*, No. 32, 1924.

A well-printed, bound and illustrated book of 100 pages, prepared for the use of American farmers. There are fourteen chapters dealing with such subjects as what it takes to make a farm business, what crops to grow and what stock to keep, and how to get the farm work done, the use of credit in farming, and how to succeed in co-operative marketing. It is perhaps too general in its treatment of American conditions to be of direct use in this country, but it is a useful indication of the kind of practical work which may be done. A.W.A.

ATLAS.

An Agricultural Atlas of England and Wales.

Prepared by Mr. J. Pryse Howell on behalf of the Institute of Research in Agricultural Economics, University of Oxford; and published by direction of the Ministry of Agriculture and Fisheries, by the Ordnance Survey. Price 10/- net.

An atlas of Wales prepared by Mr. Pryse Howell was published some time ago. The present atlas of England and Wales, apart from covering a larger area, is much more complete in the matter of details than was the earlier atlas. The idea is to show by means of dots, each dot representing a certain unit, on outline maps of England and Wales on which the county boundaries are shown, the distribution of crops and stock as they were in 1918. There are in all twenty-two maps, together with separate Geological, Rainfall and Relief maps, all on the same scale. The geological, rainfall and relief maps are loose and fitted to a pocket attached to the cover. The paper on which the agricultural maps are printed is sufficiently transparent so that by placing the loose geological or rainfall map underneath, the distribution of the various crops and classes of live stock may be correlated with the main geological features or the rainfall in different parts of the county. The maps are on the 1/1,500,000 scale, or 23.67 miles to the inch. But even on this small scale it is surprising how the details are clearly brought out. The maps are based on the parish returns collected by the Ministry of Agriculture. These were plotted out originally on large scale maps showing the parish boundaries and then reduced to the scale in which the maps appear in the atlas.

The preparation of the atlas must have entailed a very large amount of work, reflecting great credit on Mr. Pryse Howell as well as on the well-known Oxford Institute on whose behalf it has been prepared. It should prove of real value to those engaged in the study of agriculture and especially to those whose interests are mainly with the economic aspects of the subject. But it is not only to agriculturists that the atlas is valuable. It is equally useful to the teacher of rural science and the exponent of modern geography. C.B.J.

CO-OPERATION.

Report on Co-operative Marketing of Agricultural Produce in England and Wales. *H.M. Stationery Office.*

This report is the result of an enquiry into the development of the co-operative marketing of agricultural produce in England and Wales. An outline is first given of the beginning and progress of co-operative marketing up to and including the present time. A description follows, in more detail, of the development of Societies formed for the marketing of a commodity or a group of commodities. Examples are given of Societies dealing with each of these commodity groups, showing the extent of the Societies' activities, management, capitalisation and finance; methods of collection, preparation for market and disposal of commodities; relations with members as to supplies and payments, advantages resulting from the existence of such societies, causes of failures, etc.

The Report emphasises the necessity of making a thorough survey of all points of importance, such as probable scope and support of a society if formed, facilities for marketing, etc., before a society is formed.

From an examination of the working of these societies the Report concludes that

(1) A society should only be set up in a district where there is a prospect of sufficient trade to employ an efficient manager and to operate with comparatively low overhead expenses;

(2) That members should contract to supply all or a definite part of their produce for a fixed period, so that the society is assured of a regular supply and thus reduce operating expenses and marketing risks;

(3) That members should be prepared to accept only part payment for their produce until the actual receipts from the sale of such produce are known, the surplus afterwards being divided among members in proportion to the value of the commodities supplied. H.J.M.

The Co-operative Purchase of Agricultural Requisites.

H.M. Stationery Office.

This Report, prepared by the Markets and Co-operation Branch of the Ministry of Agriculture, reviews the Co-operative Societies in England and Wales formed wholly or mainly for the purpose of purchasing farmers' requisites. Taken in conjuction with an earlier Report (The Co-operative Marketing of Agricultural Produce), it provides a fuller account of the extent to which farmers in England and Wales have embraced Co-operation as a means of purchase and sale, than has yet appeared in print.

An interesting historical outline of the development of Co-operative Purchasing Societies is first given. This is followed by a classification of

Societies into three groups according to their methods of distribution of goods to members.

1st. Societies of a somewhat simple nature which mainly purchase goods as members require them, the goods being sent directly from the supplier to the members' nearest station.

2nd. Societies which provide storage accommodation for requisites purchased in large quantities in anticipation of members' demands. These goods are collected by the members from the stores or warehouse.

3rd. Societies which provide storage accommodation, but at the same time deliver goods to some or all of their members' premises.

A general description of the organisations' methods of purchase, capitalisation, relation of members to their Society, management, financial results, etc., and causes of success or failure in each Group is given, illustrated by a more or less detailed account of the working of two or more Societies in each Group, with special reference to any special features making for success or failure.

The extent to which Societies federate for trading purposes and the relation of Societies to the Co-operative Wholesale Society are briefly dealt with.

A final chapter deals with causes of failures; among which the following may be mentioned: the formation of Societies without preliminary investigations into the trading conditions in the district which are likely to make for success or failure, and capital required; facilities for transport, etc.; bad management; sale to members at a price which does not allow a sufficient margin to cover marketing expenses, risk, etc.; lack of working capital, and half-hearted support by members.

This Report should be of special interest to Welsh farmers in that the outstanding success of certain Welsh Societies is stated to be due to the fact that their members have appreciated the fact that only through the adoption of Co-operative principles and loyalty on the part of members can a Society succeed. H.J.M.

Report upon Larger Scale Co-operative Marketing in the United States of America.

H.M. Stationery Office.

This Report gives an account of the rapid development of large-scale co-operative marketing of agricultural produce in America.

The survey begins with a sketch of agricultural developments in America during the last sixty years, indicating the gradual trend towards organised systems of marketing by farmers themselves to secure better prices for their produce.

The size, distribution, membership and turnover of these large Co-operative Societies are then commented upon. The special features characteristic of these Societies in contrast to the smaller English type are:

1. The larger scale association formed on a commodity basis, covering the whole of one or part of many States. These Associations are of two types, the Federal and the Centralised. The Centralised Association places complete control of marketing in the hands of one directing agency at headquarters; while the Federal Association allows the district branches to market their own produce, advice as to the best markets, etc., being given from headquarters.

2. Membership contract, whereby members must, under penalty for breach of contract, sell all or a fixed quantity of their produce through the Society for a definite period.
3. A pooling system whereby goods of the same grade belonging to different members are pooled before marketing, thus lowering operating expenses; the members being paid at the end of the pool, which lasts for a definite time, in proportion to the produce supplied by them.

H.J.M.

Diminishing Returns; The Law of.

W. J. SPILLMAN and EMIL LANG. World Book Company, New York.

The "Law of the Soil" and the "Law of the Minimum," the "Law of Diminishing Increment" and the "Law of Diminishing Returns" form the subject matter of this book. The treatment is scientific and mathematical. The meaning of these laws and their application to the facts of plant and animal growth and to the investment of economic resources in land and stock are illustrated by figures embodying the results of experiments conducted in America and Germany.

It is a familiar phenomenon that a second unit quantity of fertilizer does not ordinarily produce as great an effect as the first unit; this is the "Law of the Soil." Similarly, a second unit quantity of feed given to a fattening animal does not give the same increase of weight as the first unit quantity. Both these phenomena, together with the fact that profits decrease proportionately with successive applications of capital and labour may be grouped as illustrations of the "Law of Diminishing Increment" or of the "Law of Diminishing Returns." The authors prefer to reserve the last named term for money returns, nevertheless the idea embodied in both laws is the same. The data examined in the book leads the writers to the conclusion that the effects of extra doses of fertilizer, feeding-stuffs or capital tend to form the terms of a decreasing geometric series; that is, there is a well-defined constant percentage decrease.

Scientists know that for a maximum yield a certain amount of each of the several external factors, like heat, light, moisture, etc., is required. This amount may be called the "optimum." The "Law of the Minimum" states that the change in the yield of a crop is affected most by a change in the minimum factor, that is, by the factor differing most in quantity from the optimum. It is correct to say, also, that a change in any factor which is itself below the optimum will affect the crop. The "Law of Diminishing Returns" applies in that the successive increases in yield follow a curved line and grow smaller with successive additions to the quantity of the factor concerned.

Agriculturists, economists and statisticians will find in this small volume new light on old problems and much data for theorizing.

W.K.

Electric Power in Agriculture.

Journal of the Royal Agricultural Society of England. Volume the Eighty-fifth.

This paper is an account of existing practice in electrical engineering, so far as it is applicable to agriculture. It is the result of an investigation undertaken at the request of the Research Committee of the Royal Agricultural Society.

R

The possible applications of electricity to agriculture are of two kinds. First, where there is some specific electric action, as in the stimulation of growing crops by a high pressure electric discharge; secondly, where electric currents are used, as in ordinary engineering practice, to drive motors or provide light.

Under the first heading the investigators consider:—

1. The electrolytic treatment of seeds.
2. The electric treatment of ensilage.
3. The electric sterilisation of milk.
4. The electro-culture of growing crops.
5. The reduction of the draught in ploughing.

The second section opens with a treatment of the general problem of mechanical power in agriculture and deals with the value of electric energy in farm operations. The supply of current may be drawn from a public or private plant, but much will depend upon the probable demand. If the demand is sufficiently great and constant and if conditions permit there is no reason why a central power station should not be established. Existing examples of electrification are described and it is suggested that the difficulty of carrying high-pressure mains over a sparsely populated country can be evaded either by a village supply or by private installations worked by water-turbines, windmills or oil-engines.

Future progress will be along two lines. First, in the development on farms of uses for electricity; and secondly, in the improvement of generating plant, especially as regards its adaptation to small-scale uses. As a source of initial power it is probable that the water-turbine and the windmill will see most change. W.K.

GRAIN TRADE.

1. Report of the Royal Grain Inquiry Commission.

Pub. by *Dominion of Canada.*

A detailed report on the subject of the handling and marketing of grain in Canada, and in particular on the following matters:—

(*a*) The grading, mixing and weighing of grain.
(*b*) The handling of grain by country and terminal elevators.
(*c*) The operation and control of terminal, public and private elevators.

2. The Canadian Wheat Pools.

PROFESSOR C. R. FAY. *Economic Journal,* March, 1925.

A short concise account of present-day methods of marketing wheat in Canada.

3. Growth and Organisation of the Canadian Grain Trade.

Journal of the Royal Agricultural Society of England. Volume the Eighty-fifth.

A detailed treatment with statistics and illustrations.

4. Economic Resources of Canada.

Report by SIR HENRY REW, K.C.B. *Ministry of Agriculture and Fisheries, Economic Series,* No. 3.

In this report Sir Henry Rew states that the present economic position of Canada appears uncertain to the casual observer, for its progress seems

to have been checked by certain causes of which the war was the greatest. He views the main fields of Canadian agricultural and economic life. Descriptions of the land and its people with their races and distribution are followed by a survey of the political and social organisation of this vast country. Attention is given to the mineral resources of the Dominion, but the opinion is expressed that Canada must for many generations be one of the chief sources of food supply for the world and therefore for Great Britain.

Grain-growing has increased seven-fold in the past fifty years. Wheat occupies four-fiths of the total land under crops, oats are grown in great abundance and a large acreage is under barley. A considerable section of the report is devoted to the economics of wheat growing and of wheat marketing. The distributive system now in vogue has been developed gradually by the co-operation of the Government, the railways, the shipping companies and the grain merchants; its various parts have been brought to a high degree of co-ordinated efficiency. The country elevators, conspicuous objects at almost every railway station in the wheat growing districts, number nearly 4,000. A country elevator is a building designed and equipped to receive, weigh, store and ship grain in bulk. The grain is lifted to the top of the building and from thence it flows downward to bin, car or truck. Large terminal elevators to which the country elevators are tributary are situated at the ports of Fort William and Port Arthur.

It is worthy of note that about half of the Canadian wheat crop of 1924 was marketed through large co-operative associations. These associations own many of the country elevators, all of which together with any private elevators which may exist, are under the control and supervision of the Board of Grain Commissioners, a Government body established by Act of Parliament. All elevators must hold a Government license. In October, 1923, the Alberta Co-operative Wheat Producers, Ltd., the first Wheat Pool, commenced business. The object of the Pool was to secure co-operation for the more advantageous placing of grain on the world's markets. A steady supply of wheat and the best price for the producer was to be the ultimate aim. Saskatchewan and Manitoba followed. The membership of these pools is now said to be in the aggregate about 92,000, representing a wheat area of eleven million acres. If a united selling agency is established for these three provinces it may have a powerful effect on the course of world wheat prices.

The production of meat in Canada, in comparison with grain-growing and even with dairying, is relatively small, though a developing industry. The "embargo" on the import of Canadian stores into this country ceased on April 1st, 1923. Sir Henry is of the opinion that no appreciable harm has been done to British agriculture, no benefit has accrued to the British consumer and no substantial advantage has yet been gained by Canadian cattle breeders.

There are four appendices showing the types of agreement, contract, charter and byelaws of the Canadian co-operative wheat producers' associations. W.K.

Fire Insurance; Farmers' Mutual—in the United States.

V. N. Valgren. *University of Chicago Press.*

So little is known in this country of the insurance of agricultural risks that all information bearing on the subject is of value. This book is an

authorative and fairly full description of the methods by which American farmers have secured a system of mutual insurance of fire risks. In 1921 the farmers' mutual companies numbered 1,952 and their risks in force were approximately $8,411,000,000, or, say, £1,682,000,000. Chapters deal with the development of these companies, their present organisation and methods of operation, and intercompany co-operation, while special problems like those of inspection of risks and classification, with windstorm and live-stock insurance, are discussed. Although some of the material of this book will be strange to British readers, they will not fail to be interested in the efforts and achievements of American farmers in this field. It is a valuable addition to the literature of agricultural insurances.

A.W.A.

LAND; ECONOMICS OF.

The Tenure of Agricultural Land.

C. S. ORWIN and W. R. PEEL. Cambridge University Press.

The questions discussed in this little book are of fundamental importance to the existence and future well-being of British agriculture. Economic pressure is forcing the old land-owning class out of existence. So many farmers have acquired their holdings within the last five years that at the present time 25 per cent. of the total area under crops and grass is farmed by owner-occupiers. They have great difficulty, however, in finding capital to cover both the cost and maintenance of their land and to finance current expenses. Farmers have realised, therefore, that there is no worse landlord than borrowed money.

The way out seems to lie in the direction of the tenancy of state owned land. The theme of this book is that although special causes have resulted in a doubling both of the acreage of land and of the number of holdings farmed by owner-occupiers in the period from 1919 to 1924, individual ownership cannot be a permanent solution of the problem of land tenure in this country.

After an interesting summary of the principles and proposals of the old land reformers and of existing associations, the writers give details of their suggested scheme. The idea is that all land not urban or industrial should be acquired by the State at a sum based upon the annual value for Income Tax and capitalised at twenty-two-and-a-half years' purchase of this amount. There would be special cases like woodlands, which are valued for Income Tax purposes at the unimproved or prairie value of the land, leaseholds which include ground-rent and buildings, and others.

The work preliminary to conveyance is to be carried out by the State without expense to the vendor, and National Land Stock issued to him to the value of property passing. Stock and Bonds would be redeemable at a long date by a Sinking Fund involving no charge on the Exchequer, but created out of the surplus revenue accruing to the State from the land owned by it. The administration of the scheme would devolve on a new branch of the Ministry of Agriculture and Fisheries called the Administration of Lands Branch, with County and District Land Agents as local representatives.

The book concludes with a very valuable chapter on the gains and losses likely to result from the operation of such a scheme. The State would benefit through being able to obtain land easily for public purposes

and for small holdings, if these were demanded. Afforestation and the development of timber resources would be stimulated. The business of taxing land would be simplified and the preservation of places of historical interest be facilitated. The danger that political influences would be brought to bear to reduce rents to the State does not appear to the writers to be worthy of consideration. The industry, on the other hand, would gain, because State ownership would give security and uniform conditions of tenure and thus promote better farming. Uniform conditions would bring nearer to solution the problems of credit, co-operation and the spreading of information. The re-adjustment of farm boundaries would be possible and the necessary permanent equipment and repairs, which present landlords are obliged to neglect, would be provided. W.K.

Elements of Land Economics.

R. T. Ely and E. W. Morehouse. Published by Macmillan & Co.

In the entire absence of any English text-book of this character, this American book may be heartily recommended. It deals with the economics of ownership and use of land for agriculture, forestry and building purposes, with property rights in water, with land values and valuation, and land taxation. There is a chapter on utilisation of agricultural land which is interesting and of considerable value. A.W.A.

MONEY AND PRICES.

(a) Report of the Committee on Stabilisation of Agricultural Prices.
H.M. Stationery Office, 1925. 1/6.

(b) The Economics of Agriculture with special reference to the Lag between Expenditure and Receipts.

By C. Dampier Whatham, M.A., D.Sc., F.R.S., pp. 122–159. *R.A.S.E. Journal*, 1924.

(*a*) The problem of the stabilisation of prices is the economic question of the day. The above report is the second in the series of reports on economic subjects connected with agriculture which the Ministry is issuing.

Messrs. A. W. Ashby, R. R. Enfield and E. M. H. Lloyd, in their covering letter to the late Minister of Agriculture, point out that they have been concerned to bring out the principles underlying stabilisation of prices and especially the bearing on the problem of the agricultural stream of tendencies abroad.

The report in its introduction (Section 1) examines the bases of the problem, *i.e.*, general monetary causes and the variations in the volume of production and the conditions of marketing particular commodities.

Section 2 deals with the changes in the general level of agricultural prices owing to monetary causes and the consequences of monetary instability. It concludes this Section with an examination of the proposals of the Genoa Conference relative to finance and other proposals for monetary stabilisation.

Section 3 consists of three main chapters; the first gives the changes in agricultural prices owing to variations in the volume of supplies (of pigs, potatoes, wheat, beef, mutton, hops and eggs); the second gives the consequences of these variations in the volume of supplies and deals especially with wheat, fruit and vegetables. The resultant state of unorganised marketing and the economic losses resulting in inefficiency and lack of confidence are next treated. The third chapter in the section is a

comprehensive survey of the remedies suggested for the variations in the volume of supplies—both home and foreign.

This report is the most remarkable production for 1/6 that we have ever read; it is a treatise on economic monetary theory to begin with and an application of the principles of currency and finance to agricultural products—their production and sale. Existing machinery for marketing is reviewed and the authors indicate that monetary causes are at the root of most of our price fluctuations even of agricultural products. This report should be in the hands of every agriculturalist and student of economics, as everyone must grasp the facts it contains before stabilisation of prices can ever be realised as a practical solution.

(*b*) The article in the *Journal of the Royal Agricultural Society* covers partly the same ground as the report. It deals with the economic lag on an East Anglian arable farm and on a West County dairy farm, and points out the effect of the results of this analysis in agricultural policy on the problem of the stabilisation of prices. The diagrams and charts are extraordinarily clear and easy to grasp by a layman—the conclusions reached that the costs of production on an arable farm are incurred for double the period of that on a dairy farm before the products are marketed are far-reaching. "A normal economic lag of 13.77, or say 13.8 months, indicates that an arable farmer's expenditure is incurred on an average 13.8 months before his receipts come in," while for a grassland dairy farm the normal economic lag is only 7.0 months. The bearing of these investigations on the importance of understanding the forces that determine prices and marketing conditions are obvious; while the imperative necessity of stabilisation of prices is clearly indicated. J.M.R.

Food Prices; First Report of The Royal Commission on.

Vol. I. Cmd. 2390. 3/6.

There is an extraordinary amount of good material in this report and after reading the facts one is surprised that the Commission was not bolder in its conclusions. One should therefore read very carefully the Minority Reports by Mr. T. H. Ryland and by Mr. W. R. Smith, J.P.

The First Report is divided into an introduction and seven parts; then follow notes and reservations, a summary, annexes, minority reports and an index.

Part I is a general examination and survey of food prices and consumption, production taxation, transport charges, wages, trade disputes, etc. Bread is dealt with in Part 2, a description of the trade is given, the cost of production and distribution and bakers' profits are examined. Similarly in Part 3 the milling trade is passed under review. Part 4 deals with wheat, Part 5 with meat in its retail trade aspects, and Part 6 with meat in its wholesale and import trade aspect. Part 7 examines State trading in food and the proposed functions of the Food Council. A note by Mr. W. T. Layton follows and reservations by Sir Henry Rew, Mr. I. Stephenson, J.P., and Mrs. Philip Snowden.

It is admitted that some consumers of bread and meat have to pay an unfairly high price for loaves and joints; but the report gives no method of measuring unfairness in price except in so far as the Food Council may perform this function for us.

The data in this report and the evidence in Vols. 2 and 3 should be carefully noted by all students of agricultural economics and also by all who wish to study marketing and descriptive economics. J.M.R.

The Miller's Margin.—A Study of Prices of Wheat, Flour and Offals.

By A. W. ASHBY, M.A. *R.A.S.E. Journal*, pp. 109—121.

This is a scientific study of the probable margin between the market price of wheat, both imported and English, the price of the corresponding flour and offals and taking into account the average moisture, impurities, etc. In view of the recent interest taken in the price of the 4 lb. loaf, this article deserves careful study, for while it does not claim to show the net profit or loss to the miller it clearly demonstrates that we can find out fairly accurate the expansions and contractions of these margins.

The author examines carefully the data required before any correct estimate can be obtained of the miller's margin. The facts he adduces are clearly put and the argument closely reasoned and lucid. The best basis for the comparison he suggests is as follows:—"Three and a half cwts. of wheat at a flour yield of 71.5 per cent. give almost exactly one sack of flour. The remaining 28.5 per cent. of offals yields exactly one cwt. . ."

A very complicated and vexed question is handled in this article in a remarkably clear and expert manner. J.M.R.

ENTOMOLOGY.

Acarine Disease; an easy method of eradicating.

SANCTUARY. (For a description of this disease see Ministry Leaflet No. 395). *Bee World*, VII, June, 1925.

The method described consists of forming a nucleus from diseased stocks, robbing the nucleus of flying bees, and strengthening it by the addition of more brood. As a bee is said to begin infecting others about five weeks after becoming infected itself, anything that removes the majority of flying bees in a colony will prove a severe shock to the progress of mites in the colony. Twelve stocks were so treated, having an initial infection of from 50 to 90 per cent. After over-wintering, in April, fifteen bees were examined from each hive, one infected bee in all was found.

J.R.W.J.

Acarine Disease; Notes on.

SAMMON and GATENBY. *Scientific Proceedings of the Royal Dublin Society*, N.S. XVII, 6 August, 1924.

Various possible methods of killing the causative mite *Acarapis woodi*, without killing the bee, are discussed. Among them is that of killing the mite in the tracheae, by feeding the bees on some substance that might so affect the haemocoel fluid of the host as to make it toxic to the parasite. The authors conducted experiments to this end during the winter months of 1923—1924. Various substances were added to the commercial candy given the bees during those months. Of these Garlic juice of 15 per cent. strength in water, with candy added according to the thickness of food desired, gave satisfactory results. One stock beginning with a 10 per cent. infection remained fairly uniform except for a sudden rise in December, and then fell until all bees examined were negative. The stock in August was still negative and healthy. It is pointed out that Garlic can easily be grown by beekeepers and the juice expressed from the bulbs and made up to 15 per cent. with candy. J.R.W.J.

Aphides attacking Vegetables and Market Garden Crops.

THEOBALD. *Journal of the Royal Horticultural Society,* L. 1 January, 1925.

A list is given of all important aphid pests of these crops. Each is subsequently dealt with individually, and an account given of its appearance and life history, and of the control measures to be adopted.

J.R.W.J.

Black Currants; Reversion Disease of—Means of infection.

LEES. (For a description of this Disease see Ministry Leaflet No. 377) *Annals of Applied Biology,* XII, 2 May, 1925.

The results of the investigations described may be summarised as follows:—Evidence is put forward showing that the disease can be propagated by contact of diseased material with healthy, either by grafting, or by pruning with a contaminated pruning tool. The disease after it has attained entry, is propagated slowly downwards, the rate of progress appearing to depend on the intensity of the original infection. There is some evidence to show that the intensity of the resulting disease is similarly dependent. It is shown that propagation of the disease can be independent of the Black Currant Mite, *Eriophyes ribis,* but there is evidence in support of the possibility of a pest carrier. There is no evidence in support of the occurrence of the disease solely on the ground of proximity of healthy and infected plants. J.R.W.J.

Certain Maggots attacking the Roots of Vegetables; Further Experiments in the Control of.

SMITH. (For a description of these pests see Ministry Leaflets, Nos. 31, 38, 122 and 303). *Annals of Applied Biology,* XII, 1 Feb., 1925.

The life histories of the four insects concerned in these trials, *Hylemyia antiqua,* Meig. (Onion fly); *Psila rosae,* F. (Carrot fly); *Phorbia (Chortophila) brassicae,* Bch. (Cabbage root fly); and *Ceuthorrhynchus pleurostigma,* Marsh. (Turnip Gall Weevil), are somewhat similar, the larval stage in each case being spent in the roots of the various vegetables. The experiments described show that a Nicotine Sulphate dust in a 5 per cent. mixture with precipitated chalk is the best substance against *H. antiqua* and *P. rosae.* Creosote in a 1 per cent. mixture in chalk gave promising results against the latter, but is not considered an efficient remedy against *H. antiqua,* which may also be treated with a 1 per cent. mixture of chlor-cresylic acid with chalk. The experiments against *P. brassicae* are preliminary, the best results having been obtained with green tar oil, chlor-cresylic acid and creosote. Tests of the value of mercury bichloride against this pest gave results which, although not conclusive, do not justify its use. Observations on *C. pleurostigma* show that the health of attacked plants is impaired in the seedling stage, but that given good conditions at the time of setting out, cabbages will flourish normally.

J.R.W.J.

Egg-killing Washes.

LEES. *Journal of Pomology and Horticultural Science,* IV, 2, Jan., 1925.

The author describes the results obtained by the application of certain spray fluids to the eggs of *Aphis pomi,* the Permanent Apple Aphis. (For a description of the pest see Ministry Leaflet No. 330). It was found that both in the controls and in every other comparable case, the eggs laid on Malling Type II stocks proved more viable than those on Malling Type

V. Lime sulphur, at all strengths tried with or without calcium caseinate, failed to show definite egg-killing power. Tar Distillate washes gave general good results, and the method of testing is accurate enough to show the effect of a difference in strength of the wash applied, of 2 per cent. Commercial Cresylic Acid, whether made up with soap as a wet spray, or with dry carriers as a dust, failed to show egg-killing power.

J.R.W.J.

Frit Fly; Certain aspects of the damage to Oats by the.

(For a description of this pest see Ministry Leaflet No. 202).

FRYER and COLLIN. *Annals of Applied Biology*, XI, 3—4, October, 1924.

The experiments described dealt with the attack of the second generation of the Frit Fly on Oat grains, and showed conclusively the value of early sowing, 4 per cent. of the early sown grain being infested and 16 per cent. of that sown later. Indications were obtained, however, that it may be possible to sow the grain too early. It was found that the period of maximum susceptibility of the Oat spikelet lies approximately at the time of fertilization. Although tests to determine the susceptibility of different varieties were not conclusive, as a result of the tests, a list is given of thirteen varieties in the order of their susceptibility so far as it is known.

J.R.W.J.

Leaflets; Ministry of Agriculture and Fisheries.

The following leaflets have been recently issued, re-written or otherwise amended.

No. 1. *Black Currant Mite.* Revised March, 1925.

In order to obtain cuttings free from mite, dipping in a nicotine insecticide is recommended in place of the hot water treatment previously advised. For diseased bushes, a single spraying with a Lime Sulphur wash winter strength when the leaves are small is now advised in place of the Lime and Sulphur or Soft Soap and Sulphur treatment.

No. 5. *Mangold Fly.* Revised March, 1924.

Reference is made to the value of natural enemies in the control of this pest, which is described, and recommendations given for artificial control.

No. 7. *The Wheat Bulb Fly.* Newly issued March, 1924.

A full description of the pest is given, together with symptoms of attack, and methods of control. The danger of sowing wheat after fallow and the value of early rolling to promote tillering are emphasised.

No. 21. *The Warble Fly.* Revised June, 1923.

The use of a lime and tobacco powder wash as the maggots become ripe is advocated. Full directions are given for the preparation of the wash and its subsequent application.

No. 31. *The Onion Fly.* Re-written March, 1924.

Particulars are given of the most recently discovered methods of combating the pest.

No. 37. *The Bean Aphis.* Newly issued, May, 1924.

Full particulars are given of the pest and the nature and extent of the injury caused by it. Control measures are discussed in detail, and the value of spraying with nicotine is emphasised.

No. 94. *Millipedes and Centipedes.* Revised July, 1925.

The most recent methods of control are discussed, and reference made to the value of dusting the drills with super-phosphate in preventing attack on pea and bean seeds.

No. 123. *Cucumber; Cultivation, Diseases and Pests of.* Newly issued, July, 1925.

Inter alia, the most common pests of this crop are described and control measures given in each case.

No. 124. *Vegetable Marrow; Cultivation of.* Newly issued May, 1925. *Vide* No. 123.

No. 125. *Melons; Cultivation, Diseases and Pests of.* Newly issued May 1925.

Vide No. 123.

No. 132. *Slugs and Snails.* Re-written September, 1923.

The commonly injurious species are described, and particulars given of the most recent methods of control.

No. 150. *Pea and Bean Beetles.* Re-written November, 1923.

The pests are described, the nature and extent of damage discussed, and particulars are given of control measures such as fumigation of attacked seeds with Carbon Bisulphide or Carbon Tetrachloride.

No. 202. *The Frit Fly.* Revised April, 1924.

The pest and its effect on cereals are fully described and its control discussed. The value of early sowing of spring Oats on a good tilth is emphasised, and in extreme cases the sowing instead of winter varieties, which suffer little or no damage.

No. 259. *Swift Moths.* Re-written January, 1924.

The pest and the damage caused are described, and control measures discussed. Attention is drawn to the value of naphthalene in this respect.

No. 303. *The Turnip Gall Weevil.* Re-written March, 1925.

The pest and its effect on attacked crops are described, and control measures suggested. Attention is drawn to the value of early lifting and either feeding off as soon as possible or stacking in large heaps to dry. Both measures result in high larval mortality.

No. 377. *Black Currant; Reversion or Nettleheads of.* Revised February, 1925.

The disease, and the possibility of its transmission by the Big Bud Mite are discussed in the light of recent research. Control measures are recommended.

No. 395. *Bees, Adult Diseases of.* Re-written September, 1924.

The result of recent researches enables additional recommendations to be made as to the control of these diseases. J.R.W.J.

Rose; The Eemies of the.

THEOBALD AND RAMSBOTTOM. *National Rose Society, London,* 1925. Price 7s. 6d.

The life histories of the more important insect pests of the rose in Britain are described, and instructions given for their control. Nicotine

is recommended as the best general wash for roses, especially as it does not damage either foliage or blossom. J.R.W.J.

Strawberry; Purple Leaf Blotch of.

BRITON-JONES. *Annual Report, Agricultural and Horticultural Research Station, Long Ashton, Bristol,* 1923.

Field observations on Purple Leaf Blotch in 1923 showed that in many cases over 50 per cent. of the total leaf surface was destroyed. The disease was due to attack by a strawberry aphid, *Myzus fragariella,* Theo., while the leaves are still unfolded. Remedies have not yet been investigated, but observations indicate that spraying will not be successful owing to the difficulty of penetrating between the unfolded leaves.

J.R.W.J.

Tetrachlorethane; Its use in Horticulture as a fumigant for White Fly.

PARKER. *Horticultural Trades Journal,* 5th May, 1925.

It is pointed out that the fall in price from thirty-six shillings a gallon to seven shillings a gallon permits the use of this effective White Fly fumigant. Particulars are given of fumigation methods and of the varying strengths required to achieve different objects. The substance has no effect on Aphids or Mites, but at high concentrations is fatal to larvae of the Tomato Moth and to Mealy Bug on Vines. J.R.W.J.

Wild White Clover; A Disease of—caused by the Eelworm Tylenchus dipsaci (*Kühn*), Bastian.

WARE. *Annals of Applied Biology,* XII, 1, February, 1925.

The appearance of Wild White Clover plants attacked by this disease is described, some are killed outright, while others survive from six to twelve months. This disease is partly responsible for the lack of permanence sometimes ascribed to strains of White Clover. Tests of the susceptibility of various clovers to infection by strains of nematodes from diseased Wild White Clover showed that Red Clovers are remarkably resistant, while White Clovers are very susceptible. These results are of interest in that they are directly opposite to those obtained by Goodey (see the *Welsh Journal of Agriculture,* 1, p. 231). This investigator, however, used strains of *T. dipsaci* taken from diseased Red Clover for his infection experiments, and it is suggested that with future tests of the susceptibility of various plants to this parasite, the former hosts of the eelworm should be considered, since the relative susceptibility of leguminous plants to eelworm attack may depend as much upon the particular strain of eelworm present as upon any faculty of resistance possessed by the plants themselves. J.R.W.J.

Woodlice; Control of.

SPEYER. *Nursery and Market Garden Industrial Development Society, Limited, Experimental and Research Station, Cheshunt, 9th Annual Report,* 1923.

Of the various fumigants tested for the destruction of this pest in the soil, phenol at the rate of one part to 1,000 parts of soil was found to be effective without any retarding effect on the seed. The most successful poison bait employed was composed of Oatmeal 50 parts, Potassium bichromate 1 part, Glucose 2 parts, Water 30 parts. J.R.W.J.

FORESTRY.

Boxwoods.

SAMUEL J. RECORD and GEORGE A. GARRATT. *Bulletin No. 14, Yale School of Forestry, August,* 1925, pp. 81; 6x9; 8 full-page plates and 2 text figs. Price 50 cents, post paid.

The distribution of the trees as well as the structure, properties and uses of the woods is dealt with and three keys are included. W.S.J.

Empire Forestry Journal.

Vol. 4, No. 1, 1925. London: The Empire Forestry Association, Imperial Institute. Price 4/-.

The above is the only issue of the *Empire Forestry Journal* which has appeared since the publication of the first number of the *Welsh Journal of Agriculture.* In addition to the Editorial Notes and Miscellanea, which cover a wide variety of interesting subjects, the volume contains, besides Correspondence and Reviews, articles on the following subjects:—

Early Days out West; Sand Dune Reclamation in Palestine; Development of Forestry in British Honduras; Research in Forestry in India; Forest Management and Working Plans in Burma; Forest Policy in British Columbia; Development of the Forestry Branch, Canada; Output from Canadian Forests in 1923; Forest Tribes of India; Forestry in Sarawak.

W.S.J.

Forestry Commission; Fifth Annual Report of the.

London: His Majesty's Stationery Office, 1925. Price 1/-.

Though this publication is primarily and essentially a report for the year ending September 30, 1924, it opens with a review of the Commission's work during the first five years (1919—24) of its existence. Then follows an article on Forest Policy during 1924; a lengthy discussion of Operations —Forest Year, 1923—24; and short statements relating to Unemployment Relief and the Total Employment in the Commission's Forests. The report closes with two Appendices as follows:—

Appendix i.—Imports of Timber, Wood Manufactures and Pulp of Wood.
Appendix ii.—Census of Production (1924); Form of Schedule.

A map showing acquisition of land is included in the Report.

The Commission has, in addition to its Annual Reports, issued up to date six Bulletins and sixteen Leaflets (including three published originally by the Ministry of Agriculture). W.S.J.

Growth in Trees and Massive Organs of Plants.

D. T. MACDOUGAL and FORREST SHREVE. Washington: Carnegie Institution, May, 1924, pp. 116. Price $1.50.

This work is divided into two Parts, as follows:—

Part I. Dendrographic Measurements (MacDougal).

The author points out that "dendrographic measurements of trees were begun in the autumn of 1918 and have been so extended that at present (close of the season of 1923) records of the growth of trees to a total of about ninety seasons, representing twenty-one species are available."

This Part closes with a summary extending to nearly eight pages.

Part II. The Growth Record in Trees (Shreve).

The work here recorded was "undertaken with a view to enlarging our

knowledge of the growth record in trees, with particular reference to the Monterey pine, and with additional work on the redwood."

The conclusions are briefly summarised at the close of the book.

W.S.J.

Manual of Forestry.

Vol. III. Forest Management, including Mensuration and Valuation. SIR WM. SCHLICH, F.R.S. London: Bradbury Agnew and Co., Ltd., 1925. Price 20/-.

We may be permitted to express our unfeigned joy that the distinguished author of this classic of English Forestry literature was enabled to complete and issue before his passing the fifth edition of his volume on Forest Management. The volume has been in a great measure re-written and much new matter has been added. W.S.J.

Preservation of Wood; The.

A. J. WALLIS-TAYLER. London: Wm. Rider and Son, Ltd., 1925, pp. XIX, 344. Price 10/6 net.

This is a second edition of a work first published in 1917. The following are the principal contents:—

Ch. I. Introduction.
Ch. II. The Destruction of Wood by Decay and the Ravages of Insects.
Ch. III. Seasoning or Drying Wood.
Chs. IV, V and VI. The Preservative Treatment of Wood.
Chs. VII and VIII. Principal Preservative Agents and Processes.
Ch. IX. Various Proprietory and other Preservative Solutions.
Ch. X. The Absorption Limit and Life of Preserved Wood.
Ch. XI. Fire-Proofing and Fire-retardant Treatment of Wood.
Ch. XII. Cost of Preservative Treatment.
Appendix. Useful Formulae. Tables, Memoranda, etc.

W.S.J.

Properties and Uses of Wood; The.

ARTHUR KOEHLER. New York: McGraw-Hill Book Co., Inc., 1924. Price $3.50.

The purpose of this book is to present in as non-technical a manner as is consistent with clearness and accuracy the more important facts concerning the properties of wood and to show how these properties affect its utilization. The contents are divided into chapters dealing with the following subjects:—

Structure of Wood; Physical Properties of Wood; The Mechanical Properties, or Strength, of Wood; Factors affecting the Strength of Wooden Members; Chemical Properties of Wood and their practical Application; Air Seasoning of Wood; Kiln Drying; Deterioration of Wood; Protection of Wood against Decay and Fire; Principal Factors governing the Use of Wood; Kinds and Quantity of Wood used for various Purposes; Measurements of Timber Products; Commercial Grading and Standard Sizes of Lumber. W.S.J.

Quarterly Journal of Forestry.

London: Laughton and Co., Ltd. Price to non-members 2/6 per issue.

Up to the date of writing three issues had appeared during 1925. The January number was the first of Vol. XIX, and with the commencement

of a new volume a change was introduced into the constitution of the Journal; each number now opens with an Editorial and Official Information is "relegated to the end." In addition to these and Notes, Correspondence. Reviews, etc., the three numbers under notice comprise the following "Original Articles":—

Volume XIX, No. 1, *January,* 1925.—Reafforestation with Cedar (*Juniperus procera*), Shume Forest Reserve, Tanganyika Territory; Intensive Silviculture; Thinning Practice (*continued*); Clear Cutting or Shelterwood; The Conifer Spinning Mite or Red Spider.

Vol. XIX, No. 2, *April,* 1925.—Norfolk Woodlands, from the Evidence of Contemporary Chronicles; Sample Plots at Huntly Manor, Gloucester; Thinning Practice (*concluded*); The Japanese Larch; Arboretum Notes.

Vol. XIX, No. 3, *July,* 1925.—The Replanting of Cleared Areas (followed by comments from the pens of a number of distinguished Silviculturists); New Forests in East Anglia; Commercial Forestry; Arboretum Notes. W.S.J.

Timbers of Tropical America.

SAMUEL J. RECORD and CLAYTON D. MELL. New Haven. Yale University Press, November, 1924. Pp. XVIII, 610; 6½ × 10; 51 full-page plates. Price $10.

The short space available renders it impossible more than merely to notice some of the salient features of this very important addition to Forestry literature. It is a book of great merit and Mr. Mell and Professor Record have placed students of Forestry and commercial users of timber under a great debt of gratitude to them. The ground covered by the book is very extensive and its contribution to our knowledge of tropical forests and timbers is very great.

Part I. The Countries and their Forests (Mell). "Presents a general view of the tropical American countries with respect to their forests and various factors involved in their exploitation and development." Matters of population, topography, climate and accessibility are considered in relation to the utilization of the timber as "they are frequently of even greater concern than the nature and extent of the forests themselves."

Part II. The Trees and their Woods (Record). "Deals with seventy-five families having trees growing naturally in tropical America, the emphasis being placed upon those of greatest interest from a commercial standpoint." Each of the seventy-five families is introduced by a short statement giving particulars of its size, distribution and economic importance. Then follows a discussion of the genera and in very many cases a description in detail of the structure of one species.

The book is well printed and admirably illustrated. W.S.J.

LIVE STOCK.

Animal Genetics; An Introduction to the Science of Animal Breeding.

CREW, F. A. E. *Biol. Monog. and Manuals.* Oliver and Boyd, 1925.

It is a tribute to the excellence of this book that it can be recommended as a text-book for students, as a work of reference to biologists generally, and, at the same time as a volume which is suitable for the lay reader who is prepared to take some trouble in mastering the technicalities of a

new science. In that the author presents in comparatively small compass all the relevant facts in proper perspective and also with the aid of a very complete bibliography provides a guide to the literature, the book fills a distinct gap.

A considerable section deals with problems of sex-determination, of sex-differentiation and of sex-ratios. The place of these subjects in the logical unfolding of the science in these chapters brings out clearly the essentially physiological basis of genetics. Genetics can no longer be confined to a study of Mendelian ratios and the simple consequences of factor interaction, nor can it remain a complex mathematical theory even if the mathematical theory has a sound cytological basis. We are still ignorant of the causes of mutation, of the nature of the gene, and of the relationships between the gene and its expression, and it is one of the merits of Dr. Crew's book that these facts are so clearly recognised and that possible lines of advance emerge so naturally.

The applications of genetics to practical problems such as hybrid vigour, resistence to disease, and many disputed beliefs are dealt with adequately and concisely. J.A.F.R.

Bibliographia Genetica.

Vols. I and II, edited by J. P. Lotsy and H. N. Kooiman, Martinus Nijhoff, The Hague.

An encyclopaedia of genetics to be completed in about ten volumes.

Comprehensive articles are included by specialists in every branch of the subject, a feature being made of complete bibliographies in each case. This work will be particularly valuable to all students of genetics, not only because each separate subject is unified but because much new information, or information difficult to obtain from other sources, is made available.

Two volumes have now been published and contain several monographs of interest in connection with the breeding of livestock. First and foremost should be mentioned a 260 page monograph by Morgan, Bridges, and Sturtevant on the genetics of Drosophila, which gives for the first time in a single volume a comprehensive account of heredity in a species on which is based at present the bulk of genetical theory. Heredity in rabbits and guinea-pigs is dealt with by Castle and its place in the development of the subject makes Punnett's monograph on *Lathyrus odoratus* a specially interesting one. The genetics of the sheep by the reviewer and Crew is dealt with elsewhere.

The volumes are beautifully got up. J.A.F.R.

Cattle Breeding.

Proceedings of the Scottish Cattle Breeding Conference. Edited by G. F. Finlay. Oliver and Boyd, 1925.

It is always a difficult matter to present the results of scientific research in a manner that will be intelligible to the lay reader and that will stimulate him to further reading, and also in such a manner that the practical application of scientific principles becomes clear. In the attempt to perform this service for those who are interested in agricultural matters the Conference held in Edinburgh in 1924 and the report of its proceedings included in the present volume will take a high place.

The editor is to be congratulated on the skill with which he has made up into a logical and comprehensive account of the subject a series of papers dealing with the most diverse topics. The book is divided into

three sections. The first deals with "scientific aspects of cattle breeding," and gives in scientific language an account of the whole subject from the origin of cattle and the formation of breeds to performance standards and progeny tests and the interpretation of milk records. The next section contains reviews of cattle breeding investigations. Among the papers of importance in this section may be mentioned one by Yapp on the inheritance of percent. fat content and other constituents of milk, and an extremely valuable paper by Gowen on "Genetic and Physiological Analysis of Cattle Problems." This paper summarises some of the results attained by the Maine Agricultural Experiment Station and is especially useful in that many of the previous papers are not readily accessible to the non-scientific reader in this country.

The third section includes reviews of the cattle breeding industry in various parts of the world and in the world as a whole and should be of great interest to the practical breeder. J.A.F.R.

Cattle Breeding; Recent Developments in.

FINLAY, G. F. Oliver and Boyd, Edinburgh, 1924.

This little book gives a short and simple account of scientific principles in cattle breeding. Emphasis is laid on their application to practical problems.

Cattle; Coloursided.

WRIEDT, C. *Jour. Hered.*, Vol. 16, No. 2, 1925.

The term "coloursided" is applied by the author to a pattern which occurs in many different breeds of cattle in various parts of the world and is seen in its typical form in this country in the Longhorn breed. It is also seen in Shetland cattle and in the old Glamorgan breed. A very similar pattern is sometimes seen in non-pedigree Black Welsh cattle.

The author has observed the result of crosses with several breeds, the coloursided parents being in nearly every case Telemark cattle crossed to self-coloured animals (Red Poll, Troender, Aberdeen-Angus). The F_1's all showed a modified coloursided pattern, the back-cross to self-colour giving the F_1 type and self-colours. There is no record of the production of coloursided offspring from self-colour $\times$ self-colour matings; on the other hand coloursided animals when interbred sometimes give piebald animals.

Crosses with red piebald Swedish cattle showed the same incomplete dominance, but with Friesians dominance was complete, the back-cross resulting in the two parental types.

The author concludes that the pattern is incompletely dominant in all the cases mentioned, but completely dominant to the Friesian marking and that it depends essentially on a single factor. J.A.F.R.

Cattle; Inheritance of Black and Red Coat Colours in.

CAMPBELL, M. H. *Genetics*, Vol. 9, No. 5, 1924.

The University of Illinois has for some years been conducting experiments involving the crossing of Friesians and Guernseys. An examination of 291 matings in this herd shows that red and black are to be regarded as an allelomorphic pair. The significance of this and other work is shown by the fact that an F_2 from *white* Shorthorns and Aberdeen Angus included reds and roans—that is, a white animal is a "red-white," or a "black-white." The earlier conception of red, black, and white as an allelomorphic series is erroneous. J.A.F.R.

Goat; The Inheritance of Horns in the.

ASDELL, S. A. and CREW, F. A. E. *Jour. Genet.*, Vol. 15, No. 3, 1925.

An examination of the Herd Book of the British Goat Society and of private herd books provides strong support for the contention that the horned and polled conditions in goats constitute a Mendelian pair of characters, the polled condition being dominant. Thus in the matter of horn growth goats resemble cattle and not sheep. J.A.F.R.

Mendelian Analysis of the Pure Breeds of Livestock. III. The Shorthorns.

MCPHEE, H. C. and WRIGHT, SEWALL. *Jour. of Hered.*, Vol. 16, No. 6, 1925.

From the point of view of the application of biological principles to breeding practice this remarkable paper is of the greatest interest and importance. It represents an attempt to "interpret the history of the Shorthorn breed on the basis of the values of certain Mendelian coefficients." Three points are considered; first, to what extent has inbreeding been practised? secondly, what is the relationship of the breed as a whole to certain outstanding sires? and thirdly, to what extent is the breed homozygous in the Mendelian sense?

Ingenious statistical methods are employed to obtain definite mathematical expressions for the quantities. The "coefficient of inbreeding" relative to the situation in 1790 has varied as follows:—

1810	16.6 ± 0.7
1825	19.9 ± 1.2
1850	18.0 ± 1.2
1875	27.4 ± 1.3
1900	22.9 ± 1.2
1920	26.0 ± 2.0

The high coefficient at the present time is due not to the actual mating of immediately closely related animals but to the fact that the breed as a whole is inbred. The relatively high level of inbreeding which was attained before 1825 must be attributed to the direct influence of the Colling bred stock. The slight drop between 1825 and 1850 represents a period when the influence of the best bred herds was being diffused through the breed. The rise which followed indicates renewed attention to the building up of closely bred families. The figures for the present day show that there has been a decrease in heterozygosity of 26 % relative to 1790, due to inbreeding alone apart from that due to selection.

The relation of the breed as a whole to the bull Favourite rises from 0 in 1790 to 44 % in 1810 and 51 % in 1825. It has remained fairly constant since then; it stands at 55 % at the present day. This result means that so far as unselected characters are concerned the whole breed to-day resembles Favourite slightly more than the average resemblance of sire and son among the original stock. The relationship of Champion of England to the whole breed was 26 % at his birth and rose to 46 % in 1920. This increase of 20 % represents the percentage of Champion of England blood in the breed at the present day.

A measure of the homogeneity of the breed at the present time is obtained by ascertaining the "coefficient of relationship" of animals selected at random. The figures are as follows:—

1810	22.0 ± 2.8
1825	26.8 ± 2.5
1850	33.9 ± 3.1
1875	37.8 ± 3.2
1900	39.3 ± 3.2
1920	39.5 ± 3.2

There has been little active inbreeding since the foundation period.

"The indications are that the breed is practically in equilibrium in all of these respects, an equilibrium which can only be disturbed by the formation and diffusion of the influence of a new closely-bred family. . . The increased size of the breed makes the difficulty of exerting an influence comparable to that of the earlier bulls enormously greater."

J.A.F.R.

Pig; Hermaphroditism in the.

CREW, F. A. E. *Jour. Obstet. and Gynaecol.*, Vol. 31, No. 3, 1924.

A previous paper by the same author, reviewed on p. 239 of the first volume of this journal, dealt with a certain type of mammalian intersexuality, the thesis being advanced that the cases there described were to be attributed to a varying time-relation in the sex-differentiation of males. In the present paper two distinct classes of intersexes in pigs are described. The first class is similar to that already noted, the second is characterised by the presence of ovarian and testicular tissue. This may take the form of one ovary and one testis, one or both gonads may be ovotestes, while in one case two ovaries and two testes were present. The ovarian tissue invariably appeared to be normal but the spermatic tissue was degenerate to some extent. An explanation is advanced on the lines already laid down: if these intersexes are genetic males the result would be due to an early excess of "female determining substance" rapidly counteracted by the corresponding "male determining substance." It is pointed out that these individuals may be genetic females, in which case the scheme is merely reversed. The question would seem to be readily amenable to experimental treatment. J.A.F.R.

Research Workers; Statistical Methods for.

FISHER, R. A. *Biol. Monog. and Manuals,* Oliver and Boyd, 1925.

The special value of this book lies in the fact that it deals largely with methods that have been developed to meet the requirements of scientific research workers. Previous works have treated in great detail processes that are applicable to very large samples normally distributed and so on, while in practice the available data are often few in number and their distribution is far from normality. The exposition of accurate methods of dealing with such data has long been a pressing necessity and it is this necessity which is so successfully met in the volume under review.

J.A.F.R.

Sex-ratio and the Question of its Control.

CREW, F. A. E. *Internat. Rev. Agric., N.S.,* Vol. 2, No. 3, 1924.

A very useful review, with a complete bibliography, of a subject of great importance to stockbreeders. J.A.F.R.

Sheep; Colour Inheritance in.

I. Black Colour and Badger-face Pattern in Welsh Mountain Sheep.

ROBERTS, J. A. F. *Jour. Genet.*, Vol. 14, No. 3, 1924.

The subject matter of this paper was briefly discussed in Vol. I of the *Welsh Journal of Agriculture*, pp. 36—37. J.A.F.R.

Sheep; Fertility in.

NICHOLS, J. E. *Jour. of Min. Agric.*, Vol. 31, No. 9, 1024.

Statistical data are presented dealing with some 20,000 sheep. The conclusions arrived at are that fertility varies mainly with these factors which tend to produce a high proportion of multiple births, there being apparently a correlation between barrenness and low percentage of twins. The practice of "flushing" leads to a high yield of lambs. Multiple births tend to occur at a time which corresponds to the period of greatest sexual activity. Barrenness and abortion are largely due to environmental conditions, but hereditary factors are also involved. The sex ratio was 97 males per 100 females. J.A.F.R.

Sheep; The Genetics of the.

ROBERTS, J. A. F., and CREW, F. A. E. *Bibliog. Genet.*, Vol. 2, 1925.

A review of the literature bearing on inheritanee in sheep; a bibliography is included. J.A.F R.

Shorthorn Colours.

SMITH, A. D. B. *Jour. Hered.*, Vol. 16, No. 3, 1925.

The simplest conception of the inheritance of Shorthorn colours is adopted, viz., a single factor difference between red and white, with roan as the heterozygote. The author examines certain alleged exceptions. First of all some animals are registered as reds when actually they are very dark roans and behave as such in breeding; this disposes of the contention that an excess of reds occur in some red × white matings. In the same way very light roans are sometimes classed as whites. These observations together with an inevitable inaccuracy in herd book records are sufficient to dispose of the 5.8 % deviation from theory found by the author.

The question of red-and-whites in Shorthorns has been much discussed. The author shows that this is probably due to a single principal recessive factor which gives a sort of piebald effect in either red or roan. Naturally modifiers would also play their part in the total effect. It is interesting that there appears to be in Shorthorns a type of spotting similar to that found in Friesians. J.A.F.R.

Swine; Blue and White Colour in.

CREW, F. A. E. *Jour. Hered.*, Vol. 15, No. 9, 1924.

In some parts of England Large White boars are mated to Large Black sows to give a popular type of blue-and-white pig; the blue patches are due to white bristles on dark skin. In some matings black-and-white pigs occur, *i.e.*, black hairs on dark skin; when this is the case the proportion is roughly one to one. The explanation is advanced that only blue-and-whites occur when the Large White individual is homozygous for a factor restricting pigment to the skin not present (naturally) in Large Blacks. When the Large White is heterozygous for

this factor half the offspring will be blue-and-white and half black-and-white. The remedy when the unwanted black-and-whites occur is to test the Large White boars. J.A.F.R.

Vererbungsversuche und Beobachtungen an Schweinen.

KRONACHER, C. *Zeit. indukt. Abstamm. & Vererb.*, Vol. 34, Nos. 1/2, 1924.

This paper deals with the results of experiments conducted at several centres in Germany, in which crosses were made to determine the inheritance of colour, pattern, and body form in pigs. The breeds used included Large Blacks, Berkshires, improved native German Landschwein, Half-Red Bavarian Landschwein, White German Edelschwein, and Hannover-Braunschweigschen Landschwein.

As regards colour it was found that uniform colours were generally dominant to broken colours. The principal factors suggested were:

R and S. Two factors for white, usually homozygous in Edelschwein and improved Landschwein. *r* and *s* when homozygous gave red and black respectively, *rr* predominating over *S* when present, and *ss* over *R*.

N. The dominant black as in the Large Black. In the presence of dominant white gives blue. The three factors exhibit incomplete dominance. No definite factors were discovered responsible for stripes and markings of various kinds but there were indications of genetic action.

In the case of body and head form the F_1's were usually intermediate. The inheritance of ear form was complicated; lop ears were usually dominant to erect ears, but more than one factor was usually involved.

J.A.F.R.

PLANT PATHOLOGY.

American Gooseberry Mildew; Control of.

O. DIETRICH. *Deutsche Obst-ü Gemusebauzeit,* 1925, lxxi, pp. 80—81 (from *Review of Appl. Mycol.*, iv., No. 6, 1925).

One of the best methods of combating American Gooseberry Mildew is stated to be wide planting. This facilitates air circulation and avoids the warm stagnant atmosphere which is so favourable to the fungus.

In 1924 the writer obtained excellent control of the disease by spraying with one per cent. Solbar on May 20th and June 20th. In spite of unfavourable weather conditions the bushes remained free from infection throughout the season and there was no injury to the foliage.

D.E.G.

Apple and Pear Scab.

E. S. SALMON and W. M. WARE. *Journ. Min. Agric.*, 1924, XXXI, pp. 546—550.

The paper refers to the occurrence of the perithecial stage of the apple and pear scab fungi in England. Methods of control by spraying with Bordeaux mixture or Lime-Sulphur are explained. D.E.G.

Celery; Dusting seedbeds to control "Blights."

A. G. NEWALL. *Phytopathology*, 1925, 15, No. 1, p. 50.

Both bacterial blight (*Pseudomonas apii*) and late blight (*Septoria apii*) have frequently been found on plants in the seedbeds. It has been shown that dusting the seedlings two to four times with 20—80 copper lime dust at weekly intervals before transplanting has greatly reduced subsequent development of blights, thus increasing the yields. D.E.G.

Clubroot of Cabbge; Control of.

G. P. DARNELL-SMITH. *Agric. Gaz. New South Wales*, XXXV, p. 488, 1924 (from *Rev. Appl. Mycol.*, IV, No. 2, p. 75, 1925).

Clubroot of cabbage and other crucifers (*Plasmodiophora brassicae*) may be controlled in the seedbed by watering the seedlings with a solution of corrosive sublimate (one oz. in two galls. of water). To control the disease in the field, crop rotation, the burning of refuse from susceptible hosts, and the application of lime at the rate of 150 bushels per acre are recommended. D.E.G.

Control of Bunt in Wheat; Use of Copper Carbonate for the.

(1) L. E. MELCHERS and H. B. WALKER. *Kansas Agric. Expt. Stat. Circ.* 107 (from *Review of Appl. Mycol.*, 1925, IV, No. 1).

Treatment may be effected in about $1\frac{1}{2}$ min. by using a concrete mixer, a large churn or a barrel mixer. The copper carbonate dust should be of 90—98 % purity (giving 50—55 % metallic copper) and 90 % of the dust should pass through a 200 mesh screen. The dust is mixed at the rate of two oz. to the bushel of seed. This dusting has not been found to give complete control when the seed is black with smut. O.R.M.

(2) G. F. PUTTICK. *Journ. Dept. Agric. for S. Africa*, VIII, pp. 616—622 (from *Review of Appl. Mycol.*, 1925, IV, No. 1).

As the result of two years' experiments at Patchefstroom School of Agriculture it was found that the dry dust copper carbonate method did not affect the germinating power to any appreciable degree, even after five months' storage, while the infection of the resulting crop was only about 0.3 % higher than in the case of seed treated by the formalin sprinkle method. Observations indicate that the grain thus treated is less readily attacked by weevils, moths, rats and mice. O.R.M.

(3) R. F. NOBLE. *Agric. Gazette of New South Wales* (from *Review of Appl. Mycol.*, 1925, IV, No. 1).

Defective germination in a wheat stand was found to be due to infection of the grain by *Penicillium glaucum*, the presence of which is stated to indicate injury to the seed previous to sowing. An imperceptible cracking of the seed coat during harvesting, etc., may involve severe damage not only from moulds but also owing to the penetration into the grain of the copper sulphate used in seed treatment. The use of copper carbonate is stated to obviate the risk of any such injury, while effectively controlling bunt and stimulating early growth of the seedlings. O.R.M.

Crown Gall Disease of Nursery Stocks.—Field Observations on Apple Stocks.

H. WORMALD and N. H. GRUBB. *Ann. Appl. Biol.*, 1924, XI, pp. 278—291.

Certain types of apple stocks propagated from layers at the East Malling Research Station having proved very susceptible to a disease which was apparently crown gall (*Bact. tumefaciens*) the authors have carried out a study of the field conditions under which the disease has been observed. They conclude: (1) That it is exceptional for galls to develop at the point of union of scion and stock above ground level. (2) Certain varieties used as stocks are much more susceptible than others. (3) No difference in vigour could be detected in the subsequent general growth of trees planted with or without galls. D.E.G.

Fruit Trees; Silver Leaf Disease of.

F. T. Brooks. *Journ. Min. Agric.*, 1925, XXXI, pp. 954—957.

The Early Rivers, Pershore, Greengage, Purple Egg, and Monarch varieties of plums are stated to be attacked comparatively rarely by silver leaf. Apples are less susceptible than plums, sweet cherries are seldom attacked and pears are almost completely immune. D.E.G.

Harvesting and Storage of Apples and Pears; Studies relating to.

H. Hartman. *Oregon Agric. Expt. Stat. Bull.* 206, 1924 (from *Review of Appl. Mycol.*, IV, No. 1, 1925).

The results of investigations carried out at Corvallis, Oregon, during 1923 on the harvesting and storage of apples and pears grown in the Willamette valley are described in considerable detail. The investigations dealt chiefly with such subjects as loss of weight during storage, time required for ripening in store and the correct time for picking. Core rot seems to be associated with over maturity. No evidence of this trouble was observed in Bartlett and Comice varieties, except in lots picked late in the season. D.E.G.

Polyporus adustus as a wound parasite of Apple Trees.

F. T. Brooks. *Trans. Brit. Mycol. Soc.*, Vol. X, Pt. III, pp. 225—225.

This polypore, which is of common occurrence as a saprophyte on stumps of broad leaved trees, is stated to have caused considerable damage to apple trees in the Wisbech district. The fungus enters through wounds and causes cracking of the bark and disorganization of the wood. Fruiting branches are often attacked in this manner, but no case of the killing of an entire tree has been observed. The most seriously affected varieties are Newton Wonder and Lord Derby, but no variety in the Wisbech area has proved to be immune. Protection of the wounds with Stockholm tar and with gas tar is quite useless—as has previously been found to be the case as a protection against the silver leaf fungus (*Stereum purpureum*). Better results have been obtained in preventing the latter disease by covering wounds with thick red-oxide paint or white-lead paint, and it is suggested that these substances would also prevent the polypore fungus from entering the wounds. Further work is being carried out by the author. T.W.

Potato Degeneration Diseases; Effect of environment on.

R. W. Goss and G. L. Peltier. *Nebraska Agric. Exper. Stat. Res. Bull.* 29.

Results showed clearly that light, soil moisture, and soil temperature have very little or no effect on the foliage symptoms of any of the degeneration diseases studied. Air temperature was found to be the most important factor studied in the masking of the foliage symptoms. O.R.M.

Potato Wart; The Dissemination of—by Animal Manure.

Tempel. Die Kranke Pflanze, I, 8, pp. 154—155, 1924 (from *Rev. Appl. Mycol.*, IV, No. 5, 1925).

The test carried out by the author is regarded as affording definite proof that the spores of the fungus causing wart disease of potatoes (*Synchitrium endobioticum*) are not destroyed by their passage through the

alimentary canal, and that the use of manure from slaughter houses is a dangerous practice, which is likely to spread the disease in fresh localities, especially where imported live stock is used. D.E.G.

Runner Beans; A Bacterial Disease of.

R. W. BUTCHER. *Expt. and Research Stat., Cheshunt, Tenth Annual Report,* 1924, pp. 66—69.

The disease, which is ascribed to *B. carotovorus*, first appears some three or four weeks after sowing the seed. The first indication is the wilting of infected plants, which are usually stunted in habit. The stem, base and roots are brown in colour and the roots are easily detached. The surface becomes corky and tends to crack and flake off. The lesions spread in an upward direction in the form of reddish-brown streaks. Inoculation tests showed that relatively low temperatures (64°F), coupled with too wet a soil, provide the most suitable conditions for this disease. In attempting a control, the soil should be kept well aerated and drained, and should be kept as warm as possible without affecting the health of the crop. It is suggested that a light dressing of stable manure dug into the top layer of soil would be advantageous. T.W.

Venturia inaequalis; Spore Dissemination of—in relation to seasonal development of Apple Scab.

C. N. FREY and G. W. KEITT. *Journ. Agric. Research,* XXX, No. 6, 1925, pp. 529—540.

By wetting leaves freshly collected from the orchard in 1917 it was shown that in the vicinity of Madison, Wisconsin, U.S.A., asci were capable of discharge, under favourable conditions, on May 7th, but natural discharge occurred only after rain on May 19th. Dew was not sufficient to induce discharge of spores of any consequence.

Bagging experiments showed that most of the leaf infection occurred between May 19th and 23rd.

Conidia were only found in the air during rainy periods. In dry weather they were difficult to remove from their conidiophores, but quickly became detached in the presence of water. In the laboratory young leaves were readily infected from conidial suspensions in water if fairly low temperatures (about 25°C) were maintained. Old leaves were highly resistant to infection. T.W.

Wart Disease of Potatoes; Experiments on the Control of—by Soil Treatment with particular reference to the use of Sulphur.

W. A. ROACH, MARY D. GLYNNE, W. B. BRIERLEY, and E. CROWTHER. *Ann. Appl. Biol.,* 1925, XII, No. 2, pp. 152—189.

During 1920—22 pot experiments were carried out to test various chemicals alone and in conjunction with steam. Steaming the soil proved effective, but offered little hope of being economically possible as a field treatment. The amount of disease was reduced by sulphur, calcium and potassium polysulphides, formaldehyde, dichlorcresol, chlordinitrobenzene and nitrobenzene. Pot experiments were not satisfactory and the method was abandoned in favour of field experiments.

Very thorough and even incorporation of chemicals was obtained by use of a Simar Rotary Tiller, and the efficiency of the treatment is said to depend upon this thorough incorporation in the soil. Experiments were carried out in 1922 with a number of substances and from these sulphur

was selected for trial in 1923, as being the most hopeful, because of its efficiency and cheapness.

In 1924, a year of heavy infection, it was proved at Ormskirk that when the dose of ground sulphur was increased through 1, 2, 3, 4, 5, 10 cwts. per acre the degree of infection was reduced in direct ratio from 73 per cent. the value for untreated soil, to 8 per cent. for an application of 10 cwt. Doses greater than the latter did not completely eradicate the disease, but this might be due to re-contamination of the soil. It is believed that 11.2 cwts. per acre of sulphur should be slightly more than the minimum necessary to free Ormskirk soil of disease.

On the heavy clay soil of Hatfield it was found necessary to use about 40 cwts. of sulphur per acre to ensure absolutely clean plots.

Gasworks spent oxides, tried as an alternative source of sulphur proved rather less effective than ground sulphur, possibly due to the unsatisfactory state of division of the spent oxides used.

Sulphur inoculated with *Thiobacillus thiooxydans* showed no increased efficiency over uninoculated sulphur on Ormskirk soils and appeared less effective than the latter on the Hatfield clay.

The authors state that the sulphur treatment will be put to a large scale critical test in 1925—6, but that the results to date seem to show that a feasible method of eradication of wart disease has been found.

T.W.

Wart Disease of Potatoes; Infection Experiments with.

MARY D. GLYNNE. *Ann. Appl. Biol.*, 1925, XII, No. 1, pp. 34—60.

A very high degree of soil moisture is necessary to ensure infection by the winter sporangia, but this need not be present during the whole growth period. It appears to be most effective when the wet period is in the second month.

A high percentage infection is obtained in potato plants grown in soils of very varying physical character.

In the pot experiments the wart organism survived in the soil in the absence of the potato plant for a period of at least a year. No wart disease was found under any conditions on immune varieties. Under favourable conditions 80—100 per cent. of the plants tested were infected within a period of three months, even in varieties which appear least susceptible in the field, but when the conditions were less favourable to infection the relative susceptibilities of the several varieties became clearly marked.

In inoculation experiments with other plants small warts were found on three out of eight varieties of tomatoes and on *Solanum nigrum* and *S. dulcamara.*

A method is described for infecting sprouting tubers with wart disease by means of summer sporangia. Susceptible varieties subjected to this treatment develop young warts within three weeks, while immunes remain clean. The method can therefore be used for testing immunity or susceptibility in the laboratory.

T.W.

SOILS AND MANURES.

Air Drying of Agricultural Soils.

A. LEBEDIANTZEFF. *Compt. Rend. Acad. Sci., Paris,* 1924, 178, No. 9, pp. 793—795.

The effect of air drying on the fertility of different Russian soils as indicated by the yields of such crops as millet, maize, oats, wheat, beets,

carrots and potatoes, is studied. Drying had a greater influence in increasing the fertility of humid prairie soils than of soils dried by cultivation and weeding. Fertilisation made soils more sensitive to drying. The effect of drying varied in the same soil, being greatest in the intermediate layers and least in the surface and the subsoils. The increase in fertility varied with degrees of drying and with the number of successive wettings and dryings. The increase was marked when the moisture was reduced to 6 % in cultivated soils and to 14 % in virgin soils. The maximum effect took place after three dryings. R.W.

Atmospheric Nitrogen Fertilisers; Field Experiments with.

F. ALLISON, J. M. BRAHM, and J. E. McMURTREY, Jr. *U.S. Dept. Agri. Bull.* 1,180, 1924, pp. 44.

The fertilising value of a large number of fertilisers containing nitrogen in different forms of combinations and in mixtures with potash salts was tested. Sodium nitrate and ammonium sulphate were used as reference substances. The results are summed up by the statement that under the conditions of the experiment all the nitrogen materials tested, with the exception of cyanamide, were of about the same value as sodium nitrate and ammonium sulphate. With regard to the last two materials, if there was any difference between them it was in favour of ammonium sulphate.

Cyanamide was not usually so satisfactory as the other sources of nitrogen, because so many factors influence the rate and manner in which this material is decomposed, either in fertiliser mixtures or in soil. Its behaviour was found to depend on such factors as time and method of application and the type, composition, temperature, and the moisture content of the soil. The soil conditions which are known to hasten nitrification are, in general, the ones which favour an efficient utilisation of cyanamide. Further experimentation is considered necessary, however, to establish more definitely the relative values of these manures and to consider the conditions under which they can most advantageously be used. R.W.

Bacterial Soil Fertilising Preparations; Experiments with.

I. A. MAKRINOFF. *Soil Science*, 1924, 17, No. 1, pp. 18—28.

Translation of contributions from the Institute of Experimental Medicine at Petrograd.

The conditions indispensable for the successful application of such preparations are a mellow soil, proper moisture content and well-selected fertilisers. It is concluded that with precautions soil inoculations may be practised on a large scale under field conditions. R.W.

Calcium Carbonate in Drainage Water; Loss of—as Affected by Different Chemical Fertilisers.

F. W. MORSE. *Soil Science*, 1924, 17, No. 3, pp. 249—254.

The amount of calcium carbonate removed from the soil when ammonium sulphate was used was more than twice as large as with sodium nitrate. Sodium nitrate added to an application of dissolved phosphate and potassium chloride protected the calcium carbonate somewhat. R.W.

Contents of Soils; Investigations of the Ammonia and Nitrate.

E. HASELHOFF and F. HAUN. *Landw. Vers. Sta.*, 1924, 102, No. 1, pp. 90—103.

Most ammonia and nitrate were found in the upper strata of both fallowed and cropped soils. The most ammonia was found in fallowed soil and the most nitrate in cropped soil. Time of the year had a lesser effect on the ammonia than the nitrate content, especially in cropped soils. In general the nitrates decreased during autumn and winter and increased during the spring and summer until the harvest time, after which they almost disappeared. Such general variations did not occur in the ammonia content. Decreases in the ammonia frequently followed increases in nitrates, although there was no regularity in such occurences. The ammonia content of the soil was, however, generally least at the harvest time. Fallowing, stable manuring, and green manuring had a marked influence on the nitrification in soils. R.W.

Decomposition of Calcium Cyanamide (Nitrolim) on Storage.

K. D. JACOB, J. KRASE, and J. M. BRAHAM. *Journ. Indus. Engin. Chem.*, 1924, 16, No. 7, pp. 684—688.

When calcium cyanamide was exposed in small lots to unusually severe conditions of humidity and temperature for long periods, the cyanamide nitrogen was completely changed to other forms, principally dicyandiamide and urea in the approximate proportions of from 70 to 75 % and from 20 to 22 % respectively of the nitrogen. From 7 to 8 % of the total nitrogen was lost as ammonia. Untreated calcium cyanamide decomposed more rapidly than the hydrated and the oiled material. When stored in bulk in such a manner that only a relatively small surface was exposed to atmosphere, as in silos, the decomposition was almost negligible, the changes being confined to top 20 cm. R.W.

Decomposition of Cellulose in Tilled Soil; Action of Stable Manure in the.

C. BARTHEL and N. BENGTSSON. *Soil Science*, 1924, 18, No. 3, pp. 185—200.

The favourable influence of stable manure on the cellulose fermentation in soils was found to be due to the nitrogen present in the manure which is available to the micro-organisms. Micro-organisms added with the manure were found of no practical importance in normal soils, since sterilised manure acted in the same manner as the unsterilised manure. The cellulose fermentation in auto-claved soil, inoculated with manure or unsterilised soil proceeded much more rapidly than in unsterilised soil. because of the ammonium nitrogen split off from the higher nitrogen compounds during sterilisation. R.W.

Development of Barley in Heavy Clay Soil; The Effect of Aeration on the.

R. V. ALLINSON. *Soil Science*, 1924, 17, No. 2, pp. 97—105.

Studies are reported in which the effect of aeration and constant flow of nutritive solution through the soil were determined on the growth of barley. The method used in the study of aeration is described in detail. The response of barley to aeration was decidedly positive. Although a constant flow of nutritive solution through the soil effected a considerable increase in the growth, these results are taken to indicate that any increase in the compactness or imperviousness of the soil may be considered to be injurious to plant growth through the consequent decrease of the supply of available oxygen. R.W.

Fine Waste and Mixed Fertilisers as a Beginning for the Industrial Use of Municipal Sewage, Garbage and Sewage Sludge; Fertiliser Experiments with.

J. BODLER. *Osndhts. Ingen.*, 1924, 47, No. 26, pp. 266—279.

The results showed that the fertilising value of sifted garbage and sludge is so much greater than its heating value as to make burning an uneconomical procedure. Mixed fertilisers containing this material were found to be specially valuable for light sandy and gravelly soils and for heavy clay soils deficient in humus. R.W.

Green Manures; The Value of Certain.

L. KOCH. *Tropic. Agri. (Ceylon)*, 1924, 62, No. 6, pp. 351—356.

Studies on the relative values of different types of green manures. The greater part of the dry matter was found to occur in the stems. This is taken to indicate that the woody parts of green manure plants are of high importance for the formation of humus. The nitrogen is confined largely to the leaves and young twigs; the woody stems and roots contain only about one-seventh to one-third of the total. The phosphate content varied widely among the different types of green manuring. R.W.

Legumes; Nitrogen Experiments with.

SCHNEIDEWIND. *Mitt. Deut. Land. Gesell*, 1924, 39, No. 18, pp. 335—336.

Nitrogen fertilisation experiments with alfalfa, peas, and lupines are briefly reported, showing that in some cases there was no profitable increase in yield and in others even a decrease with nitrogen fertilisation. The results are taken to indicate that a favourable action of nitrogen application to legumes is not always certain or profitable.

Lime and Phosphates.

Delaware Sta. Bull., 1924, p. 6.

Sixty and 100 mesh limestone materials are as effective as calcium oxide in promoting the decomposition of organic matter. The 100 mesh limestone and the calcium oxide produced very similar results with most favourable effects on the activity of the soil organisms. No appreciable difference in their effect on the availability of the soil phosphorus or soil potassium was shown by the different materials. R.W.

Liming of Land.

J. A. VOELCKER. *Journ. of Farmers' Club*, 1924, pp. 19—38.

Practical information on the different forms of agricultural lime, their manufacture and their practical use in the treatment of soils. It is stated that the matter of lime requirement of soils has not yet been definitely settled, and that the information yielded by the different methods discussed is of relative value only. R.W.

Mechanical Condition of Soils and Sub-Soils; Improvement of.

H. A. MULLETT and P. R. SCOTT. *Journ. Dept. Agri., Victoria*, 1923, 21. No. 10, pp. 583—597.

Studies on the improvement of the mechanical condition of soils and sub-soils, with particular reference to the use of gypsum are presented. Soils subject to water-logging in winter showed that gypsum increased the yield 69 % in one case and 160 % in the other. Soil samples taken from the treated and the untreated field soils showed that the colloids in the

clay sub-soils were substantially reduced in some cases as much as 40 %. This reduction is attributed to flocculation and the precipitation of the colloids in suspension. This is taken to indicate that the pore space of the soil is freed of gelatinous clay substances by gypsum and the permeability to water is thus improved. R.W.

New Phosphoric Acid Fertilisers; Experiments with.

E. Haselhoff. *Mitt. Deut. Landw. Gesell,* 1924, 39, No. 3, pp. 40, 41.

Comparative tests with superphosphate, basic slag, raw phosphate, tetraphosphate and the so-called colloidal phosphate on oats, beets, and potatoes are reported. The results have demonstrated the apparent value of the colloidal phosphate as compared with super phosphate and basic slag, and suggest the importance of further tests with this material.

R.W.

Nitrogen in Soils and Fertilisers as Affected by Lime; The Utilisation of.

J. G. Lipman and A. W. Blair. *Journ. Ind. and Engin. Chem.,* 1924, 16, No. 4, pp. 373—375.

These experiments were begun at the New Jersey experiment station in 1898. The nitrogenous manures used were sodium nitrate, ammonium sulphate, dried blood and cow manure. The results indicate that a continued use of ammonium sulphate without the application of lime has produced a soil so acid as to inhibit growth. The corresponding limed soils have produced normal crops. Heavy applications of manure tended to correct the unfavourable condition brought about by the continued use of ammonium sulphate without lime. The recovery of nitrogen by the crops from applications of cow manure and one of the commercial fertilisers containing nitrogen was usually equal to or greater than the sum of the recoveries from these materials when used singly. R.W.

Nutritive and Vitamin Value of Certain Grain; The Relation of Manure to the.

R. McCarrison. *Brit. Med. Journ.,* 1924, No. 3,300, pp. 567—569.

Studies are reported showing that in all probability natural manures are superior to artificial manures in influencing the nutritive and vitamin value of food grains. R.W.

Peat Soils; Fertiliser Experiments on.

C. J. Christensen. *Tidsskr. Planteavl.,* 1923, 9, No. 3, pp. 462—509.

Fertiliser experiments carried out on both upland and lowland peats, showing the influence of kainit and basic slag o nmeadow, oats, barley, and potatoes. The best yields were obtained when both these materials were used together. Comparative experiments with phosphatic and potassic fertilisers indicated no great difference between the various fertilisers as judged by crop yields. Sodium nitrate increased the yields on both the uplands and lowlands, the better results being obtained on the upland.

R.W.

Plant Nutrients in Stable Manure after the War; Variation of the Contents of.

O. Schiller. *Landw. Vers. Sta.,* 1923, 101, No. 5—6, p. 293.

Chemical studies of samples of stable manure representative of large and important areas in Germany are reported, showing that there has been a general decrease in the contents of nitrogen and the phosphoric acid,

but an increase in the potash since the war. This is taken to indicate the necessity of a more general use of artificial fertilisers supplying the deficient constituents. R.W.

Stable Manure in Cultivated Soils; Nitrification of.

C. BARTHEL and N. BENGTSSON. *Meddel. Centralanst. Forsoksv. Jordbruk.* (Sweden), 1924, No. 269, p. 13.

It is concluded that the lime added to the soil either in the form of calcium carbonate or as newly slaked lime and in amounts used in practice has no noteworthy effect on the nitrification of farmyard manure and that the time of liming does not alter the results. R.W.

Stable Manure; The Action of—on Potatoes when Applied in Different Ways.

D. MEYER. *Deut. Land. Gresse.*, 1924, 51, No. 4, pp. 29, 30.

The results showed that stable manure placed in the furrows gave better results in the spring than manure ploughed under. Also manure spread on ploughed land gave better results in the autumn than manure ploughed under. The residual action on the grain crops of the manure applied in the furrows was also greater than that of manure ploughed under. R.W.

Urea in the Soil; Decomposition of.

F. LITTANER. *Ztschr. Pflanz. Düng.*, 1924, 3, No. 3, pp. 165—179.

The decomposition of urea in the soil depends on the soil type, soil moisture, and temperature. Dryness retarded decomposition, but an increase in the soil moisture above the average water capacity produced no essential change in the urea decomposition. The results indicate that urea will decompose very rapidly in soils rich in bacteria and well supplied with moisture. R.W.

AGRICULTURAL BOOKS, 1924—25.

The following list, prepared by the staff of the National Library of Wales, is a selection of the books on Agriculture published during the year Oct. 1924—Sept.1925. The list supplements *The Hand-List of Books on Agriculture* issued by the National Library, second edition, 1924, copies of which can be obtained on application to the Librarian, The National Library of Wales, Aberystwyth.

App, FRANK.

Farm economics: management and distribution.
Philadelphia: Lippincott Co., 1924.
pp. 700. ill., diags., maps, bibl. ... ... 12s. 6d.

Farm management in U.S.A., also deals with the questions of marketing, prices of products, distribution, etc.

Bean, W[ILLIAM] J[ACKSON.]

Trees and shrubs hardy in the British Isles. *4th ed.*
London: Murray, 1925.
2 vols. ill., pls., bibl. ... ... 63s. 0d.

Brief descriptions of all the species, and more important varieties of hardy woody plants established in cultivation; with notes on their distinctive characters, garden value, and culture.

Bennett, F. T.

Outlines of fungi and plant diseases.
London: Macmillan, 1924.
pp. xii, 254. front., ill., diags. ... ... 7s. 6d.

In two parts:—I, An introduction to the study of fungi in general. II, Plant diseases and the fungi which cause them, with life histories of the organisms, described in the light of recent scientific research.

Berry, JAMES BERTHOLD.

Southern woodland trees: a guide to the identification of trees and woods.
London: Harrap, 1924.
pp. viii, 214. front., ill., bibl. ... ... 3s. 6d.

Berry, JAMES BERTHOLD.

Teaching agriculture: an analysis of the teaching activity in its relation to the learning process.
London: Harrap, 1924.
pp. xvi, 230. ill., diags., bibl. ... ... 5s. 0d.

All the methods outlined have been used by the teachers of Crawford County, Pennsylvania, and the book consists of four parts, or steps:—I, The problem; II, The presentation and solving of the problem; III, Application of the solution; IV, Testing.

Bowen, J. T.

Dairy engineering.
New York: Wiley, 1925.
pp. xiv, 532. ill., diags. ... ... 18s. 6d.
Wiley Agricultural Engineering Series.

Bowles, E[DWARD] A[UGUSTUS.]

A handbook of crocus and colchicum for gardeners.
London: Martin Hopkinson, 1924.
pp. xii, 186. front., pls. ... ... 12s. 6d.

Branson, E[UGENE] C[UNNINGHAM.]

Farm life abroad: field letters from Germany, Denmark and France.
Chapel Hill (U.S.A.)—London: Humphrey Milford, 1924.
pp. x, 304. bibl. ... ... $2.00.

The author is Kenan Professor of Rural Social Economics at the University of North Carolina, and whilst in Europe made a special study of farming, country communities, institutions, etc., and standards of living in the rural areas of the three countries named.

British Government Publications. *Ministry of Agriculture and Fisheries.*

British breeds of live stock. *4th ed.*
London: Ministry of Agric. and Fisheries, 1925.
pp. 138. ill. ... ... 3s. 6d.
Miscellaneous Publications No. 7.

Brown, EDWARD THOMAS.

The beginner's poultry book.
London: "Boys' Own Paper" Office, [1925.]
pp. 182. front., ill., pls., diags. ... ... 1s. 6d.

How to make coops, runs, houses, etc.

——— The poultry-keeper's text-book.
London: Ward, 1924.
pp. 320. front., ill., diags. ... ... 6s. 0d.

Bunyard, EDWARD A.

A handbook of hardy fruits more commonly grown in Great Britain. [Vol. II] Stone and bush fruits, nuts, etc.
London: Murray, 1925.
pp. 258. ... ... 10s. 0d.

Burgess, JOSEPH.

British agriculture *versus* foreign tributes.
London: Francis Johnson, 1925.
pp. xxviii, 210. ... ... 4s. 0d.

Arguments in favour of an alternative policy to Free Trade or Protection, suggested for adoption by the International Labour Party.

Castle, F. R.

Tomatoes and how to grow them: indoor and outdoor cultivation.
London: Collingridge, [1925.]
pp. 96. front., ill., diags. ... ... 1s. 6d.

Chatterton, F. J. S.

Ducks and geese: and how to keep them.
London: Cassell, 1924.
pp. xiv, 110. pls. ... ... 1s. 6d.
Pet and Live Stock ser.

Cockayne, L[EONARD.]

The cultivation of New Zealand plants.
Auckland, N.Z.: Whitcombe and Tombs, [1924].
pp. 140. pls. ... ... 5s. 0d.

Commercial.

Commercial cucumber culture: by the Lea Valley correspondent of the "Fruit-Grower."
London: Benn, 1924.
pp. 46. ... ... 2s. 6d.

Copeland, EDWIN BINGHAM.

Rice.
London: Macmillan, 1924.
pp. xiv, 352. front., ill., pls. ... ... 20s. 0d.

A brief account of the physiology of the Rice plant, and an attempt to explain the details of field practice, by their physiological effects.

Corrie, FRANK EWART.

The feeding of dairy cows.
Lingfield: The Author, 1925.
pp. 8.

——— Manuring for profitable production: a handbook for farmers and students.
London: Press and General Publicity Service, 1924.
pp. 24.

——— The mineral needs of farm stock, with special reference to the supply of lime and phosphorus to animals.
London: Press & Publicity Service, 1924.
pp. 32.

Cotter, SIR JAMES LAWRENCE, BART.

All about the rose in simple language.
London: Melrose, 1924.
pp. viii, 214. pls. (some col.). ... ... 6s. 0d.

——— The culture of bulbs: bulbous plants and tubers made plain.
London: Hutchinson, [1925].
pp. 192. front., ill., diags. ... ... 10s. 0d.

Embraces all plants under this heading known to cultivation. Designed specially to meet the needs of both the amateur and advanced horticulturists, and written in simple language.

Cox, EUAN HILLHOUSE METHVEN.

Rhododendrons for amateurs.
London: Country Life, Ltd., 1924.
pp. xvi, 112. front., ill., map. ... ... 5s. 0d.

Cox, JOSEPH F.

Crop production and soil management.
New York: Wiley, 1925.
pp. xxx, 516. front., ill., maps, bibl. ... 13s. 6d.
Wiley Farm Series.

Crew, F[RANK] A. E[LEY.]

Animal genetics: an introduction to the science of animal breeding.
Edinburgh: Oliver & Boyd, 1925.
pp. xx, 420. ill., pls., diags., bibl. ... 15s. 0d.
Biological Monographs and Manuals No. III.

A brief account of what has been, and what is being done by the geneticist, summarising recent contributions to biological research literature on stock-breeding.

Cruess, W[ILLIAM] V[ERE.]

Commercial fruit and vegetable products: a textbook.
New York: McGraw Hill Book Co., Inc., 1924.
pp. viii, 530. ill., diags. ... ... $4.50.
McGraw-Hill Agricultural and Biological Publications.

The canning and bottling of fruits and vegetables and their commercial distribution, etc.

Cunningham, ANDREW.

Practical bacteriology: an introductory course for students of agriculture.
Edinburgh [etc.]: Oliver & Boyd, 1924.
pp. viii, 188. ill. ... ... 7s. 6d.

This book originated in a series of notes prepared for the use of students of agricultural bacteriology, and is based upon Löhnis Laboratory methods.

[**Dalziel,** HUGH.]

The diseases of dogs: their causes, symptoms and treatment; *rev.* and *enl.* by A. C. Piesse. *6th ed.*
London: Bazaar, Exchange, and Mart, 1925.
pp. [iv], 158. ill. ... ... 2s. 0d.

Day, GEORGE E.

Productive swine husbandry. *4th ed. rev.*
Philadelphia: J. B. Lippincott Co., 1924.
pp. x, 384. front., ill., diags. ... ... $3.00.

Textbook for agricultural students giving, in concise form, the findings of experiment stations in regard to the problems involved in the successful handling of swine.

Douglas, CHARLES EDWARD.]

Rice: its cultivation and preparation.
London: Pitman [1924.]
pp. x, 144. front., ill., bibl. ... ... 3s. 0d.
Pitman's Common Commodities and Industries.

A general review.

Dowling, R. N.

Sugar beet from field to factory.
London: Benn, 1925.
pp. 72. ill. ... ... 2s. 6d.

An outline of the sugar beet industry and practical methods of growing beet.

Drummie, A. C.

Practical forestry from a workman's point of view.
London: Routledge, 1924.
pp. xii, 340. ill., pls. ... ... 7s. 6d.

The author has had twenty-four years of practical working forest experience, and has written this book as a guide to beginners or young assistant foresters. It is free from technicalities.

Ely, RICHARD T[HEODORE], *and* **Morehouse,** EDWARD W.

Elements of land economics, by R. T. E., and E. W. Morehouse.
New York: The Macmillan Co., 1924.
pp. [xx], 354. front., ill., pls., diags., bibl. ... $3.50
Land Economic Series.

An elementary survey of land as an economic factor, and also treats of land as a commodity from different points of view.

Erith, ADELA GWENDOLYN.

White clover (*Trifolium repens. L.*): a monograph.
London: Duckworth, 1924.
pp. x, 150. ill., bibl. ... ... 18s. 0d.

Febre, J[EAN] H[ENRI.]

Farm friends and foes: talks about the creatures useful to agriculture, by J. H. F.; trans. [from the French] by B. Miall.
London: Fisher Unwin, 1925.
pp. 312. ill., pls. ... ... 15s. 0d.

Written in the form of a conversation between an uncle and his three nephews, beginning with bats, hedgehogs and rodents, followed by chapters on the habits of owls, etc. Birds like the woodpecker and cuckoo are fully dealt with, and there is a concluding chapter on lizards, frogs, and toads.

Fairbridge, DOROTHEA.

Gardens of South Africa.
London: Black, 1924.
pp. viii, 214. col. pls. ... ... 10s. 0d.

Fielding, A. E. BRUCE.

Pig-keeping: do's and dont's.
London: Methuen, 1925.
pp. x, 82. ... ... 2s. 6d.

Written to provide the beginner in pig farming with a knowledge of the business, and the possibilities of its commercial success.

Fletcher, F. J.

Cut flowers for market.
London: E. Benn, 1924.
pp. 64. ... ... 2s. 6d.

Flower, A. B.

Bee-keeping up-to-date.
London: Cassell, 1925.
pp. x, 108. front., ill., pls., diags. ... ... 1s. 6d.

Foster, Leonard F[rederick.]

Principles and practice of farm book-keeping: a text-book for agricultural students.
London: Gee and Co., Ltd., 1925.
pp. viii, 476.

A comprehensive textbook for students attending farm institutes, and based upon the syllabuses of such institutions.

Fox, L. E.

Adam's garden: the cultivation of vegetables, tomatoes, rhubarb, and small fruit.
London: Longmans, 1925.
pp. 96. ... ... 2s. 6d.

Intended for those whose gardening is a spare time occupation.

Gray, Lewis Cecil.

Introduction to agricultural economics.
New York: The Macmillan Co., 1924.
pp. [xiv], 556. maps., diags. ... ... 12s. 0d.
Social Science Text-Books Series.

A textbook suitable for the use of students, but also adapted to the needs of the general reader interested in economic problems of agriculture. Much of the material was accumulated by the author when Professor of Rural Economics in the George Peabody College for Teachers.

Hall, C. J. *Agriculturalist.*

A short history of English agriculture and rural life.
London: Black, 1924.
pp. viii, 152. ill., pls., bibl. ... ... 2s. 6d.

A brief sketch, written as an introduction to the subject.

Handasyde, *pseud.*

The four gardens (*new ed.*).
pp. [x], 182. col. pls. ... ... 3s. 6d.

Holmes, H. R. J.

A short system of farm costing.
London: Milford, 1924.
pp. 108. ... ... 6s. 6d.

[Horace Plunkett Foundation.] *Conference on Agricultural Co-operation in the British Empire.*
Agricultural co-operation . . . in the British Empire: with an introd. by Sir H. Plunkett.
London: Routledge, 1925.
pp. [x], 28; [x], 254.

Proceedings of the British Empire Conference on Agricultural Co-operation. Most of the papers deal with fundamental principles of agricultural political economy, and the social conditions of rural life.

House, C[HARLES] A[RTHUR.]

Ducks: show and utility.
London: The Poultry Press, Ltd., [1925].
pp. 114. front., ill., pls. ... ... 2s. 6d.

Breeding, rearing, and general management of ducks for show, for the table, and for egg production. Concluding chapter on geese.

Hovell, [THOMAS] MARK.

Rats and how to destroy them.
London: John Bale, Sons, and Danielson, 1924.
pp. xlii, 466. ill., diags. ... ... 10s. 6d.

Based upon the practical experience of the author in the destruction of a large colony of rats.

Howard, ALBERT.

Crop-production in India: a critical survey of its problems.
London: Oxford Univ. Press, 1924.
pp. 200. ... ... 10s. 6d.

Sets out the problems of agriculture peculiar to India, and how they affect the development of the country.

Hunter, HERBERT.

Oats: their varieties and characteristics: a practical handbook for farmers, seedsmen, and students.
London: Benn, 1924.
pp. 132. pls. ... ... 6s. 0d.
Practical Farming Series No. 2.

Summarizes the qualities of the varieties of oats now in general use.

Jameson, H. G.

Illustrated guide to the trees and flowers of England and Wales. *2nd ed. rev.*
London: Simpkin, Marshall, 1925.
pp. xii, 140. ill. ... ... 3s. 6d.

A practical handbook for the identification of trees and flowers, pointing out the characteristics easily recognised and remembered.

Jekyll, GERTRUDE, *and* **Weaver,** SIR LAWRENCE.

Gardens for small country houses. *5th ed.*
London: Offices of "Country Life," 1924.
pp. l, 262. col. front., ill. ... ... 25s. 0d.
Country Life Library

Jones, W[ATKIN] S[AMUEL.]

Timbers: their structure and identification.
Oxford: The Clarendon Press, 1924.
pp. xi, 148. ill. ... ... 15s. 0d.

Judkins, HENRY F.

The principles of dairying.
New York: Wiley, 1924.
pp. xviii, 280. front., ill., diags. ... ... $2.00.

For the use of students in secondary schools, and beginners' courses in colleges.

King, LOUISA YEOMANS, *Mrs. Francis.*

Chronicles of the garden.
New York: Charles Scribner's Sons, 1925.
pp. xii, 276. front., pls. ... ... 12s. 6d.

Reproductions of typical houses of varying costs, accompanied by planting plans appropriate to the various styles of architecture.

Knowles, G. W.

The book of dogs.
London: Jack, [1924.]
pp. 132. front., ill. ... ... 3s. 6d.

Leighton, ROBERT.

Your dog.
London: Cassell, [1924.]
pp. x, 108. pls. ... ... 1s. 6d.

Lloyd, NATHANIEL.

Garden craftsmanship in yew and box.
London: Benn, 1925.
pp. 36. ill., pls. ... ... 15s. 0d.

The planting and cultivation of the yew, and methods of trimming hedges, arches, and clipping figures.

Loeb, JACQUES.

Regeneration from a physico-chemical viewpoint.
London: McGraw-Hill Book Co. ... ... 10s. 0d.

Lucas, JOCELYN.

Pedigree dog breeding for pleasure or profit, and where to buy a dog.
London: Simpkin, Marshall, [1925.]
pp. x, 189, xc. front., ill. ... ... 6s. 0d.

McDonald, DONALD.

Fruit culture and utility: a comprehensive and instructive companion for amateurs and young professionals.
London: Hayes, 1924.
pp. 288. col. pls., ill., diags. ... ... 6s. 0d.

M'Fadyean, SIR JOHN.

The comparative anatomy of the domesticated animals: Part I. Osteology and arthrology. *3rd ed.*
London: The Author, [1924.]
pp. vi, 210. ill., diags. ... ... 15s. 0d.

Systematic description of the anatomy of the common domesticated animals of Great Britain.

MacSelf, A. J.

Flowering trees and shrubs.
London: Thornton Butterworth, 1924.
pp. 224. col. front., ill., diags. ... ... 6s. 0d.

Concise descriptions of a large number of the most useful and ornamental species of trees and shrubs.

——— Gladioli.
London: Thornton Butterworth, 1925.
pp. 158. col. front., ill., pls. ... ... 6s. 0d.

——— The horticultural exhibitor: a guide to success.
London: Thornton Butterworth, 1924.
pp. 222. front., pls., diags. ... ... 3s. 6d.

A book of instructions to make the most and best of flowers, vegetables, and fruit grown for exhibition.

——— A real A.B.C. of gardening.
London: Thornton Butterworth, 1924.
pp. 216. col. front., ill. pls., diags., bibl. ... 6s. 0d.

Principally for those new to gardening, giving the "how and why" of simple gardening operations. It is not written in alphabetical order.

Malden, W[ALTER] JAMES.]

Actual farming: its processes and practices.
London: Benn, 1925.
3 vols. pls., bibl. ... ... 50s. 0d.

Farming under modern conditions. Mainly concerned with practice.

Mannering, ROSSLYN.

Fowls and how to keep them.
London: Cassell, [1924.]
pp. [viii], 112. front., ill., pls. ... ... 1s. 6d.
Pet and Live Stock Ser.

Practical details of management for the amateur poultry keeper.

Martineau [ALICE], *Mrs.* PHILIP.

Gardening in sunny lands:—the Riviera, California, Australia.
London: R. Cobden-Sanderson, 1924.
pp. 296. col. front., pls. ... ... 15s. 0d.

Written mainly as an elementary handbook for garden lovers unfamiliar with horticultural conditions in the South of France, and of other countries of similar climate.

Miller, MERRITT F.

The soil and its management.
Boston: Ginn, 1924.
pp. vi, 386. ill., bibl. ... ... 7s. 6d.

A practical textbook for high schools and young farmers.

Moon, FRANKLIN, *and* **Brown,** NELSON COURTLANDT.

Elements of forestry. *2nd ed. rev.*
New York: Wiley and Sons, 1924.
pp. xviii, 510. ill.

A general textbook with special application to the forest regions and state problems of the United States.

Morse, RICHARD, *and* **Palmer,** RAY.

British weeds: their identification and control. A practical handbook for the use of estate owners, farmers, gardeners, and students of agriculture, horticulture and field botany.
London: Benn, 1925.
pp. 208. front., ill., pl. ... ... 10s. 6d.

Morton, J[OHN] W[ILLIAM.]

Commercial strawberry culture.
London: Benn, 1924.
pp. 48. ill. ... ... 2s. 6d.

——— Profitable bush fruit culture.
London: Benn, 1925.
pp. 64. ill. .... 2s. 6d.

National Institute of Agricultural Botany.

Varieties of potatoes with their synonyms, immune from, and susceptible to wart disease: tested at the Potato Testing Station, Ormskirk, from 1915-1924.
Cambridge: Heffer, 1925.
pp. 32. ... ... 1s. 6d.

Orwin, C[HARLES] S[TEWART.]

Farm acounts. *2nd ed. rev.*
Cambridge University Press, 1924.
pp. [viii], 140. ... ... 5s. 0d.
Cambridge Farm Institute Ser.

Based upon accounts of actual farming experience.

Orwin, C[HARLES] S[TEWART], *and* **Peel,** W[ILLIAM] R[ALPH.]
The tenure of agricultural land.
Cambridge: University Press, 1925.
pp. x, 76. ... ... 3s. 6d.

Proposals for the reconstruction of land tenure, with special reference to the Finance Act of 1909—10, and the slump in values consequent on the deflation policy following the conclusion of Peace.

Owen, W. POWELL—
The complete poultry book.
London: Cassell, 1924.
pp. xii, 334. ill., pls. ... ... 10s. 6d.

Paterson, WILLIAM G. R., *Editor.*
Farm crops. By many specialists. Vols. I—IV.
London: The Gresham Publishing Co., Ltd., 1925.
4 vols. ill., pls. ... ... 50s. 0d.

Prothero, ROWLAND EDMUND, *1st Baron Ernle.*
The land and its people.
London: Hutchinson, 1925. pp. viii, 258 ... 10s. 6d.

Chapters in rural life and history and containing a detailed and authoritative account, by the then President of the Board of Agriculture, of the Food Production Campaign of 1916—1918.

Punnett, R. C.
Sex-linkage for egg production and table poultry.
London: The Daily Mail, [1925].
pp. 32. ... ... 1s. 0d.

Record, SAMUEL J[AMES], *and* **Mell,** CLAYTON D[ISSINGER.]
Timbers of tropical America. (The Amasa Stone Mather Memorial Publication Fund, Vol. 4).
New Haven, Conn.: Yale Univ. Press, 1924.
pp. xviii, 610. front., pls. ... ... $10.00.

The book is in two parts, the first of which deals with American countries and their forests, and the second, a description of the trees and their woods.

Reeks, H. CAULTON.
Diseases of the horse's foot. *2nd ed.*
London: Baillière, Tindall and Cox, 1925.
pp. xii, 568. ill. ... ... 21s. 0d.

A textbook for students, with recorded cases. It does not deal with the shoeing of the normal foot.

Richmond, H[ENRY] DROOP.

The laboratory book of dairy analysis. *3rd ed. rev.*
London: Griffin and Co., Ltd., 1925.
pp. viii, 118, viii. ill., diags. ... ... 5s. 0d.

Working directions for the analysis of milk and dairy products, with a chapter on the application of analysis to the solution of problems connected with the composition of milk and its products.

Sanders, *Royal Orchid Nurseries, St. Albans.*

The cultivation of orchids. Being extr. from *Sanders' Orchid Guide,* 1925 *ed.*
Belgium pr.; publ. by Sanders, St. Albans, [1925].
pp. 46. ... ... 3s. 6d.

Sanders, T[HOMAS] W[ILLIAM].

Chrysanthemums and how to grow them.
London: Collingridge, [1925].
pp. 32. ill. ... ... 7d.

——— The flower garden: its design, formation and management. *5th ed.*
London: Collingridge, [1925].
pp. viii, 472. ill., col. pls. ... ... 10s. 6d.

——— Kitchen garden and allotment. *6th ed.*
London: Collingridge, 1925.
pp. 126 [ii]. ill. ... ... 1s. 6d.

——— Roses and their cultivation. *13th ed.*
London: Collingridge, [1924].
pp. xii, 204. ill., col. pls. ... ... 7s. 6d.

——— Roses: how to grow, prune, and propagate them.
London: Collingridge, [1925].
pp. 32. ill. ... ... 7d.

——— Sweet peas: how to grow and show them.
London: Collingridge, [1925].
pp. 32. ill. ... ... 7d.

——— Violas and pansies: how to grow and show them successfully.
London: Collingridge, 1925.
pp. 32. ill. ... ... 7d.

Sanders, THOMAS WILLIAM, *and* **Landsell,** J.
Grapes: peaches: melons: and how to grow them. A handbook dealing with their history, culture, management and propagation.
London: Collingridge, [1924].
pp. [ii], 150. ill. ... ... 5s. 0d.

Schlich, SIR WILLIAM.
Schlich's manual of forestry. Vol. III. Forest management, including mensuration and valuation. *5th ed. rev.*
London: Bradbury, Agnew and Co., 1925.
pp. [x], 384. ill., diags.
Chiefly designed for the use of students of forestry.

Scott, GEORGE.
Modern poultry-keeping.
London: Black, 1925.
pp. x, 182. front., pls. ... ... 5s. 0d.
Poultry culture in theory and practice, commercial, utility, and exhibition.

Scottish Cattle-Breeding Conference.
Cattle-breeding: proceedings of the S.C.B. Conference (Edinburgh, 1924), ed. by G. F. Finlay.
Edinburgh: Oliver and Boyd, 1925.
pp. x [ii], 496. ill., diags. ... ... 12s. 6d.

Sharpe, R.
Dog-training by amateurs: a handbook of instruction for all sportsmen.
London: Country Life, Ltd., 1924.
pp. xii, 138. front., ill. ... ... 7s. 6d.

Smith, ROBERT H[ENRY.]
Agricultural mechanics.
Philadephia: J. B. Lippincott Co., 1925.
pp. viii, 358. ill., diags. ... ... $3.00.
A course of instruction on the handling and care of farm machinery and equipment.

Sutton, MARTIN H[UBERT] F[OQUETT], *and* **Jones,** D. J. COLUMBUS.
Red clover and the possibilities of improved strains.
Reading: Sutton and Sons, [1925].
pp. 32. ill., diags. ... ... 2s. 6d.
Bulletin No. 14.

Tahourdin, C. B.
Native orchids of Britain.
Croydon: H. R. Grubb, Ltd., 1925.
pp. xiv, 114. front., ill.
A non-technical work for amateurs.

Tannock, DAVID.
Rock gardening in New Zealand.
Auckland [etc.] : Whitcombe and Tombs, Ltd., [1925].
pp. 94. front., ill. ... ... 3s. 6d.

Thomas, H[ENRY] H[IGGOTT.]
Profitable small fruits.
London: Cassell, 1925.
pp. 80. front., ill. ... ... 9d.

Thomson, G. SUTHERLAND.
Butter and cheese: a commercial and technical guide to good qualities and defects.
London: Crosby Lockwood, 1925.
pp. 96. ... ... 4s. 0d.
Detailing defects in quality which enable the commodities to be graded.

Tinley, GEORGE F., *and others*.
Colour planning of the garden, by G. F. T., T. Humphreys, and W. Irving, with drawings by M. W. Anson.
London: Jack, 1924.
pp. xxxvi, 288. front., ill., pls. (some col.) ... 42s. 0d.
The study and use of colour in gardening. General principles and their application in definite schemes. The scheme of the book was originally drawn up by the late R. Hooper Pearson.

Tisdale, C[HARLES] W[ILLIAM] WALKER, *and* **Jones**, JEAN.
Butter and cheese.
London: Pitman, 1925.
pp. x, 148. front., ill. ... ... 3s. 0d.
Embodies most of the points in the manufacture of both these articles, including marketing and judging.

Townsend, G. A.
Practical rabbit-keeping.
London: Cassell, (1924).
pp. [viii], 112. ill., pls. ... ... 1s. 6d.

Turnbull, J.

Fruit growing: do's and dont's.
London: Methuen, 1925.
pp. vi, 56. diags. ... ... 2s. 6d.

Waters, HENRY JACKSON.

Essentials of the new agriculture.
Boston [etc.]: Ginn, 1924.
pp. viii, 550. col. pls., ill. $1.60

An American textbook of agriculture, written with the distinct purpose of creating an interest in agriculture, by setting out the opportunities in farming for the successful management of soil, and in the growing of crops and live stock.

Weathers, JOHN.

My garden book: prepared for the daily use of all who own a garden, big or little.
London: Longmans, 1924.
pp. xvi, 774. front., col. pls., ill. ... 36s. 0d.

The science and practice of gardening in the 20th century.

ERRATA.

VOLUME I.

Page 53. *Table. Cols.* 1, 2, 3 *and* 4. "*Number of Eggs Laid.*"

For the numbers included in table substitute the following:—

	Dry Mash.		*Wet Mash.*	
	1st grade.	*2nd grade.*	*1st grade.*	*2nd grade.*
Nov. 11 to Dec. 8	77	514	36	251
Dec. 9 to Jan. 5	166	522	140	315
Jan. 6 to Feb. 2	404	456	373	425
Totals and averages for whole period	7,923	6,714	7,616	5,940

Page 87. *Table V. Column of Relative Yield.*

The "—*" should be against "Late Flowering Red Clover alone."
88.9 against "Timothy alone."
91.2 against "Late Flowering Red Clover and Alsike plus 6.7 species of grasses."

Page 142. *Footnote on Rhos.*

For "*Erica Cinerea*" read "*Erica tetralix.*"

Page 171. *Line* 1 *of Footnote.*

For "Lyngby, 1921—23 (34)" read "Lyngby, 1921—23 (3a)."

Page 173. *Line* 34.

For "Heald (25)" read "Heald (11)."

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